FACULTY OF AGRICULTURAL SCIENCES

Institute of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute)

University of Hohenheim

Chair of Rural Development Theory and Policy

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CONSUMER ACCEPTANCE OF IRON BIOFORTIFIED VARIETIES OF STAPLE FOOD CROPS

Dissertation

submitted in fulfillment of the regulations to acquire the degree

"Doktor der Agrarwissenschaften"

(Dr. sc. agrar. in Agricultural Sciences)

to the

Faculty of Agricultural Sciences

Presented by

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Born in Colombia

- 2019 -

This thesis was accepted as a doctoral thesis (Dissertation) in fulfillment of the regulations to acquire the doctoral degree "Doktor der Agrarwissenschaften by the Faculty of Agricultural Sciences at University of Hohenheim on November 14th 2018.

Date of the oral examination: January 29th 2019

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ACKNOWLEDGMENTS

This dissertation emerged during my work in HarvestPlus, a joint program between the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI). I am deeply grateful to HarvestPlus for all the support given during those years, and this dissertation is the result of its high commitment and trust towards me since the beginning. Further, I am in particular and deeply grateful to Ekin Birol, head of the former “Impact Research Unit” in HarvestPlus, currently “Influence and Impact Pillar.” Ekin’s support and guidance were extremely valuable during the brainstorming, analysis, and writing periods this manuscript underwent. Through Skype or during my visits to Washington D.C. she was always willing to help and bring forward all the best of her expertise and knowledge.

Additionally, I also want to thank and express my gratitude to Adewale Oparinde for his guidance and in particular, for sharing his knowledge on consumer acceptance studies, econometric analysis, and article writing. Adewale has been by my side during all this process, starting in Rwanda where I had the opportunity to join him and learn about how to plan and develop consumer acceptance studies, and even today, I am still receiving his feedback and advice. Moreover, I am also extremely grateful to Prof. Dr. Manfred Zeller for being my supervisor, for his invaluable scientific advice and for reviewing this thesis.

I want to dedicate this dissertation to CIAT, the institution that has allowed me to grow personally and professionally for the past 18 years. To Carolina Gonzalez for her support and guidance for many years now as a friend, colleague and supervisor in HarvestPlus Latin America and the Caribbean (LAC), and especially during the writing process of this dissertation. I wish to thank Marilia Nutti, chief of HarvestPlus–LAC and to my friends and colleagues in CIAT and IFPRI, for their continuous support and interest in my dissertation process. Last but not least important, I want to dedicate this accomplishment to my family, in particular to my beloved mother, Aurelia, who has been my support and guide during all my life, to my sister Carime, and my nephew, Juan Pablo. To my brother Andres, who could physically not accompany me at this moment, but I know that he is always with us. Finally, many thanks to God for giving me this opportunity and letting me accomplish this challenge

EXECUTIVE SUMMARY

Micronutrient deficiency is one of the most common forms of malnutrition worldwide. Iron deficiency alone affects 2 billion people worldwide. Since 2004, HarvestPlus, a joint program between the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI), is working on the development of new staple crop varieties with higher micronutrient content using conventional breeding methods. This strategy is known as "biofortification." According to the trait that has been bred into a biofortified crop, these are classified into visible and invisible nutritional traits. In the group with visible nutritional traits, varieties enriched with vitamin A have been included because of the yellow color that they show. In the group of invisible nutritional traits, those with improvements on iron or zinc contents are included and are classified as "invisible" as no color features or characteristics can be seen in the crop.

A crop with an invisible nutritional trait represents a challenge in terms of acceptance by target consumers since these invisible traits target an invisible nutritional problem. Micronutrient deficiencies are also called hidden hunger, due to the invisibility of their consequences. Iron- and zinc-biofortified crops might be considered credence goods, i.e., goods characterized by the fact that although consumers can observe their utility, these derive from ex-post goods, and therefore, they cannot judge whether the type or quality of the good they receive is the ex-ante they needed. Further, one of the main characteristics of these products is the asymmetric information between producers and sellers on the one hand, and consumers on the other hand. For example, producers might not be aware of a particular trait as their seeds and plants do not show any visible feature, and conversely, consumers might not be aware of the needs and utility of what producers are offering to them. Subsequently, nutritional information should play an essential role in reducing the asymmetric and imperfect information characterizing iron- and zinc-biofortified crops and creating a growing market for them.

To this end, this cumulative dissertation consists of four interrelated papers. Two of them (Chapters 2 and 3) focus on the analysis of primary data collected in Guatemala, thereby seeking to contribute to the limited knowledge of farmers' and consumers' acceptance of biofortified crops in Latin America and the Caribbean. The other two papers (chapter 4 and 5) cover, apart from Guatemala, also an analysis of data from Rwanda and India. In the following chapter, I summarize each of the four papers and conclude with an overall synthesis of the results.

The first article, entitled “Consumer acceptance of an iron bean variety in Northwest Guatemala: The role of information and repeated messaging,” analyzes the acceptance of different organoleptic attributes and the willingness to pay for an iron-biofortified variety compared with a popular local variety. It addresses the first research question: What are the impact of nutritional information and its repetition on consumer’s acceptance on the main organoleptic attributes of an iron bean variety in rural Guatemala and the willingness to pay for these varieties compared with the most popular local variety? The impact of receiving information about the nutritional features and the benefits of the biofortified variety and its repetition on the valuation of the attributes tested and on the general acceptance was evaluated.

For a better understanding of how those preferences identified in the first article are formed, the second paper, “Identifying socioeconomic characteristics defining consumers’ acceptance for main organoleptic attributes of an iron-biofortified variety in Guatemala”, addresses the second research question: Which socioeconomic factors define consumers’ attitudes towards some specific attributes of an iron-biofortified bean variety in rural Guatemala? This article provides a deeper analysis of how consumers’ preferences towards some specific sensory attributes, such as color and taste, are defined by consumers’ socio-demographic characteristics. This is the first time that the socio-demographic characteristics predicting consumers’ preferences for the main sensory attributes of a biofortified variety are analyzed. This analysis allows understanding how those preferences are formed based on respondents’ characteristics and of the differences in consumer acceptance of similar varieties.

According to the literature reviewed, men are less interested in health-promoting behaviors, and healthier lifestyle patterns, so nutritional information is expected to have a lesser impact on men’s acceptance of the iron-biofortified varieties tested. A promotion strategy of a biofortified variety based on nutritional information addressed to women could be more cost-effective compared to one addressed to men, as women are generally the primary caretakers of children and they influence food purchase decisions and intra-household distribution of food. Based on this scientific evidence, the third article, “The impact of nutritional information on consumer acceptance of nutritious foods: A gendered analysis of iron-biofortified foods in India, Guatemala, and Rwanda”, addresses the third research question: Which role do gender aspects plays in the impact of nutritional information on the acceptance towards iron-biofortified crops?

Another socioeconomic characteristic evaluated is consumer market participation. There is empirical evidence that respondents’ acceptance of a new agricultural product –as a new variety– depends on whether its main role in the market is as a consumer or as a producer. Those with higher participation as a producer will be more interested in those market-oriented attributes, such as size, color, and texture. On the contrary, those that are more consumer-oriented will be interested in attributes, such as taste and time required for cooking. In this same direction, all the consumer acceptance trials with biofortified crops carried out have used grains, and respondents are in most of the cases producers who might be more interested in testing seeds instead of tasting grains when evaluating agronomic attributes. In this sense, the fourth article, “Role of respondent’s market participation on consumer acceptance towards seeds and grains of an iron bean variety” addresses the fourth and final research question: Are respondents’ primary role as consumers or producers and their participation in markets play a significant role in how iron-biofortified crops are evaluated?

To recommend nutritional information strategies a cost-benefit analysis on delivering nutritional information is required. In summary, the results presented in this dissertation suggest that farmers and consumers show high acceptance of iron-biofortified varieties in Guatemala (and two other countries as well). Moreover, the results also show a significant role of nutritional information and its repetition as a diffusion strategy depending on the interlocutors’ main socio-demographic characteristics. In the same direction, further analysis with studies specifically designed to address those issues (e.g., gender and market participation role) must be carried out in order to validate those results. The effect of these two socio-demographic characteristics on the impact of nutritional information on consumer acceptance of a biofortified crop when evaluated together must also be tested. Furthermore, the above mentioned is also highly recommended when carrying out those analyses using crops with visible traits, such as vitamin A-biofortified cassava or maize, in order to compare results and evaluate the effect of the traits’ visibility on those results.

Overall, this thesis contributes to closing several knowledge gaps that have not been addressed so far in the scientific literature: how the preferences for some specific attributes are determined by some specific socioeconomic variables and the role that information might play. This information is relevant to segment potential consumers according to those characteristics when designing a diffusion strategy for those crops.

Results found in this work shed light on which consumers’ characteristic must be considered when a diffusion strategy for biofortified crops is designed. Aspects such as gender, level of education, respondents’ role as producer and consumer, or both, their relationship to the market, among other consumers’ socioeconomic and demographic characteristics, are relevant to potentiate the impact of nutritional information and overcome some asymmetric information related to the “invisible” traits and benefits of the iron-biofortified crops. However, further research on this matter is suggested to increase the representativeness of these results.

ZUSAMMENFASSUNG

Mikronährstoffmangel ist eine der am weitesten verbreitete Form von Mangelernährung. Allein zwei Milliarden Menschen weltweit sind von Eisenmangel betroffen. HarvestPlus, ein gemeinsames Programm des International Center for Tropical Agriculture (CIAT) und des International Food Policy Research Institute (IFPRI), arbeitet seit 2004 an der Entwicklung neuer Nutzpflanzen mit einem höheren Mikronährstoffanteil, auf Basis herkömmlicher Züchtungsmethoden. Diese Strategie ist bekannt als “Biofortifikation“. Entsprechend ihrer Eigenschaften können angereicherte Nutzpflanzen klassifiziert werden in solche Pflanzen mit sichtbaren und solche mit unsichtbaren Nährwerteigenschaften. Die mit Vitamin A angereicherten Pflanzen zählen zur Gruppe mit den sichtbaren Nährwerteigenschaften, da sie eine Gelbfärbung aufweisen. Zur Gruppe der unsichtbaren Nährwerteigenschaften zählen die Pflanzen mit verbessertem Eisen- oder Zinkgehalt.

Eine Nutzpflanze mit unsichtbaren Nährwerteigenschaften stellt hinsichtlich der Akzeptanz bei der Verbraucherzielgruppe eine Herausforderung dar, weil diese unsichtbaren Eigenschaften auf ein unsichtbares Ernährungsproblem hinweisen. Mikronährstoffmängel werden auch „versteckter Hunger“ genannt, weil ihre Auswirkungen unsichtbar sind. Die mit Eisen und Zink angereicherten Nutzpflanzen könnten als Vertrauensgüter angesehen werden, was bedeutet, dass sie Eigenschaften aufweisen, deren Nutzen die Verbraucher zwar im Nachhinein feststellen können, jedoch können sie nicht vorher beurteilen, ob die Pflanze von der Sorte oder Qualität ist, die benötigt wird.

Eine der Haupteigenschaften solcher Produkte ist die Informationsasymmetrie zwischen Produzenten und/oder Verkäufern auf der einen, und Verbrauchern auf der anderen Seite. Möglicherweise sind sich nicht einmal die Produzenten über die Eigenschaft der Pflanze bewusst, da ihr Saatgut und die Feldfrucht keine sichtbaren Eigenschaften zeigt. Verbraucher sind sich möglicherweise nicht über die Notwendigkeit und Nützlichkeit der Produkte bewusst, die Produzenten ihnen anbieten. Außerdem spielen vermutlich Nährwertinformationen eine wichtige

Rolle, um die Informationsasymmetrien und/oder Informationsunvollständigkeit zu reduzieren, welche die mit Zink und Eisen angereicherten Nutzpflanzen einhergeht, und um einen wachsenden Markt für diese zu schaffen.

Diese kumulative Dissertation besteht aus vier miteinander im Zusammenhang stehenden Forschungspapieren. Zwei davon (Kapitel zwei und drei) konzentrieren sich auf die Analyse von Primärdaten die in Guatemala gesammelt wurden, und dazu beitragen sollen, mehr Wissen zur Akzeptanz von angereicherten Nutzpflanzen bei Landwirten und Verbrauchern in Lateinamerika zu generieren. Die anderen beiden Arbeiten (Kapitel vier und fünf) beinhalten weiterhin, neben Analysen aus Guatemala, eine Auswertung mit Daten aus Ruanda und Indien. Es folgt eine Zusammenfassung aller vier Forschungspapiere, und schlussendlich eine Synthese aller Ergebnisse.

Der erste Forschungsbericht mit dem Titel "Consumer acceptance of an iron bean variety in Northwest Guatemala: The role of information and repeated messaging" untersucht die Akzeptanz bei verschiedenen organoleptischen Merkmalen und die Zahlungsbereitschaft für eine mit Eisen angereicherte Bohnenvariante, verglichen mit einer verbreiteten einheimischen Sorte. Die Arbeit thematisiert die erste Forschungsfrage: Welchen Einfluss haben (wiederholte) Nährwertinformationen auf die Verbraucherakzeptanz zu den Hauptmerkmalen einer mit Eisen angereicherten Bohnenvariante im ländlichen Guatemala, und auf die Zahlungsbereitschaft für diese Sorte im Vergleich zur beliebtesten einheimischen Sorte? Die Auswirkungen des (wiederholten) Erhalts an Informationen zu Nährwerten und Vorteilen der angereicherten Sorte auf die Bewertung der getesteten Attribute und der generellen Akzeptanz wurde evaluiert.

Um ein besseres Verständnis dafür zu erhalten, woraus sich die im ersten Forschungspapier ermittelten Präferenzen zusammensetzen, befasst sich der zweite Forschungsbericht "Identifying socioeconomic characteristics defining consumers' acceptance for main organoleptic attributes of an iron-biofortified variety in Guatemala" mit der zweiten Forschungsfrage: Welche sozioökonomischen Faktoren definieren die Einstellung der Verbraucher bezüglich einiger bestimmter Merkmale einer mit Eisen angereicherten Bohnensorte im ländlichen Raum Guatemalas? Diese Arbeit erbringt eine tiefgreifende Analyse dazu, wie die Präferenzen von Verbrauchern für einige spezielle sensorische Attribute, wie beispielsweise Farbe und Geschmack, sich über die sozio-demographischen Charakteristika der Verbraucher definieren. Zum ersten Mal werden die sozio-demographischen Faktoren, welche die Verbraucherpräferenzen für die wichtigsten sensorischen Attribute vorhersagen, ausgewertet. Ausgehend von den Charakteristika der Befragten erlaubt dies ein tiefergehendes Verständnis dafür, wie Präferenzen gebildet werden, und für die Unterschiede bei der Verbraucherakzeptanz ähnlicher Sorten in unterschiedlichen Regionen oder befragten Gruppen.

Einigen Autoren zufolge sind Männer weniger an gesundheitsförderndem Verhalten und einer gesünderen Lebensweise interessiert; daher wird erwartet, dass Nährwertinformationen bei Männern weniger Einfluss auf die Akzeptanz der getesteten, mit Eisen angereicherten Bohnen haben. Eine auf Nährwertinformationen beruhende Förderstrategie für die angereicherte Sorte, die sich an Frauen wendet, könnte kosteneffizienter sein, da Frauen generell die Hauptsorge für Kinder tragen und auf Lebensmittelkaufentscheidungen sowie die Verteilung der Lebensmittel innerhalb des Haushaltes Einfluss nehmen. Ausgehend von diesen wissenschaftlichen Erkenntnissen befasst sich der dritte Forschungsbericht mit dem Titel “The impact of nutritional information on consumer acceptance of nutritious foods: A gendered analysis of iron-biofortified foods in India, Guatemala, and Rwanda” mit der dritten Forschungsfrage: Welche Rolle spielen Gender-Aspekte für die Auswirkungen von Nährwertinformationen auf die Akzeptanz bezüglich mit Eisen angereicherter Nutzpflanzen?
Das zweite sozioökonomische Merkmal, welches evaluiert wurde, ist die Teilnahme der Verbraucher am Markt. Es gibt wissenschaftliche Beweise dafür, dass die Akzeptanz der Befragten zu einem neuen landwirtschaftlichen Produkt als neue Sorte davon abhängt, ob der Befragte ein Verbraucher oder Produzent ist. Produzenten werden eher an marktorientierten Attributen wie Größe, Farbe, und Konsistenz, interessiert sein. Verbraucherorientierte Befragte sind wahrscheinlich eher am Geschmack und der Kochzeit interessiert.

Bei den Fragen zur Verbraucherakzeptanz angereicherter Nutzpflanzen wurde meistens Getreide verwendet. Die meisten Befragten sind jedoch möglicherweise eher daran interessiert, Saatgut zu testen um die agronomischen Merkmale auszuwerten. Der vierte Forschungsbericht “Role of respondent’s market participation on consumer acceptance towards seeds and grain of an iron bean variety” befasst sich mit der vierten und letzten Forschungsfrage: Spielt die Funktion der Befragten als Konsumenten oder Produzenten und ihre Teilnahme am Markt eine signifikante Rolle dabei, wie die mit Eisen angereicherten Nutzpflanzen bewertet werden?

Um Strategien zu Nährwertinformationen uneingeschränkt empfehlen zu können, ist eine Kosten-Nutzen-Analyse zur Überlieferung von Nährwertangaben notwendig. Zusammengefasst deuten die Ergebnisse dieser Dissertation darauf hin, dass Landwirte und Verbraucher den mit Eisen angereicherten Sorten in Guatemala (und zwei weiteren Ländern) eine hohe Akzeptanz entgegenbringen. Die Ergebnisse zeigen auch, dass Nährwertinformationen, und deren wiederholter Erhalt als Verbreitungsstrategie eine signifikante Bedeutung haben; allerdings hängt dies auch von den soziodemographischen Merkmalen der Gesprächspartner ab. Hier sollten weitere Untersuchungen durchgeführt werden, die spezifisch darauf ausgerichtet sind, diese Themen anzugehen (z.B. geschlechterspezifische Studien und die Bedeutung der Marktteilnahme), um die hier erworbenen Resultate zu validieren. Der Einfluss dieser beiden sozio-demographischen Faktoren, wenn sie zusammen ausgewertet werden, auf die Bedeutung von Nährwertinformationen hinsichtlich der Verbraucherakzeptanz einer angereicherten Nutzpflanze, sollte ebenfalls getestet werden. Um diese Untersuchungen durchzuführen, wird dringend empfohlen, Nutzpflanzen mit sichtbaren Merkmalen, wie etwa mit Vitamin A angereichertes Cassava oder Reis zu verwenden, um die Ergebnisse vergleichen zu können, und die Auswirkungen der Sichtbarkeit dieser Merkmale auf die Ergebnisse auswerten zu können.

Die vorliegende Arbeit trägt dazu bei, verschiedene Wissenslücken zu schließen, mit der sich die wissenschaftliche Fachliteratur seither nicht befasst hat: inwieweit die Präferenz für ein spezifisches Merkmal durch einige sozioökonomische Variablen bestimmt wird, und welche Bedeutung der Verbreitung von Informationen dabei zukommt. Diese Informationen sind relevant, um potentielle Verbraucher hinsichtlich dieser Merkmale zu segmentieren, wenn eine Verbreitungsstrategie für diese Pflanzen ausgearbeitet wird.

Die hier erarbeiteten Ergebnisse zeigen auf, welche Verbrauchermerkmale beachtet werden müssen, wenn eine Verbreitungsstrategie für angereicherte Nutzpflanzen ausgearbeitet wird. Aspekte wie Gender, Bildungsniveau, die Bedeutung der Befragten als Produzenten, Konsumenten oder beides, deren Verhältnis zum Markt, sowie die sozioökonomischen und demographischen Merkmale anderer Verbraucher, sind relevant um die Auswirkungen der Nährwertinformationen zu potenzieren und die Informationsasymmetrien die mit den unsichtbaren Merkmalen und Vorteilen der mit Eisen angereicherten Nutzpflanzen einhergehen, zu überwinden. Es wird empfohlen, weitere Untersuchungen zu diesem Thema durchzuführen, um die Repräsentativität der Ergebnisse zu untermauern.

LIST OF ABBREVIATIONS

AIC	Akaike Information Criteria
BDM	Becker-DeGroot-Marschak
BPI	Biofortification Priority Index
CADER	Rural Development Learning Centers
CLT	Central Location Testing
DID	Difference-in-Difference
FAMD	Factor Analysis of Mixed Data
FFI	Food Frequency Index
GDP	Gross Domestic Product
HH	Household
HIB	High Iron Bean
HIPM	High Iron pearl Millet
HUT	Home Use Testing
IB	Iron bean
ICTA	Science and Agricultural Technology Institute of Guatemala
IICA	Inter-American institute for Cooperation on Agriculture
IRI	Information Retention Index
LAC	Latin American and Caribbean
LM	Breusch-Pagan Lagrange Multiplier
LN	Natural logarithm
LPM	Local Pearl Millet
MAGA	Ministry of Agriculture of Guatemala
NARS	National Agricultural Research System
OLS	Ordinary Least Square Model
OSP	Orange Sweet potato
PPI	Progress out of Poverty Index
PPM	Parts per million
Prem	Premium
Q.	Quetzals
S.D.	Standard Deviation
SDGs	Sustainable Development Goals
T1	Treatment 1
T2	Treatment 2
T3	Treatment 3
US$	United States Dollar
WIB	White Iron Bean
WTP	Willingness To Pay

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1. INTRODUCTION

The main goal adopted by world leaders in 2015 as part of the Sustainable Development Goals (SDGs) was to “end all forms of malnutrition by 2030” (UNICEF, 2016). Malnutrition and poor diets constitute the number one driver of the global burden of disease. Low body weight, poor child growth, and micronutrient deficiencies cause on average, an annual GDP loss of 11% in Asia and Africa (UNICEF, 2016). Micronutrient deficiency, especially iron deficiency, is the most common and widespread nutritional disorder in the world (WHO, 2017a), affecting 2 billion people worldwide (FAO, 2013). The World Health Organization (WHO) has endorsed global targets for improving maternal, infant, and young child nutrition. Among the global targets for 2025, those related to micronutrient deficiencies are to reduce by 40% the number of children less than five years of age who are stunted, and to reduce by 50% the anemia in women of reproductive age (WHO, 2017b). The supplementation and the fortification of food have currently been the main strategies to fight anemia among children and pregnant women, but in recent years, biofortification has emerged as a complementary strategy to reduce micronutrient deficiencies as vitamin A, zinc and iron. The primary target group for biofortification is smallholder farmers in low-income countries that self-consume much of their staple food crops and lack sufficient micronutrient intake (Bouis and Saltzman, 2017). According to HarvestPlus (2017):

> by the end of 2017, approximately 30 million people were benefitting from biofortified crops in HarvestPlus’ 14 target countries across Africa, Asia, and Latin America and the Caribbean. By 2020, HarvestPlus aims to reach 20 million farming households with biofortified planting material, benefiting at least 100 million people, and by 2030, one billion people are expected to consume biofortified foods globally.

1.1 BIOFORTIFICATION

Biofortification is defined as the process of increasing the density of bioavailable vitamins and minerals in a food crop through plant breeding or agronomic practices so that when consumed regularly, the crop will generate an improvement in the vitamin and mineral nutritional status of the persons (HarvestPlus, 2018a). Biofortification is a fairly recent public health approach to controlling vitamin A, iron and zinc deficiencies in poor countries with multiple advantages as argued by Nestel et al. (2006). First, it targets low-income households because staple foods predominate in the diet of the poor; second, the multiplier aspect of the plant breeding across time and distance makes it cost-effective; third, the nutritionally improved varieties will continue to be grown and consumed year after year, even if government attention and international funding for micronutrient issues fade; and fourth, it is being argued that biofortified crops are available for undernourished people in remote rural areas where other nutritional interventions, such as fortified foods or supplementation, are expensive or not available (Nestel et al., 2006). The Copenhagen Consensus ranked interventions that reduce micronutrient deficiencies, including biofortification among the highest value-for-money investments for economic development. For every dollar invested in biofortification, benefits obtained may rise up to USD 17 (Hoddinott et al., 2012). Research findings have shown that biofortification is a cost-effective and feasible mean of reaching malnourished rural populations who may have limited access to diverse diets, supplements, and commercially fortified foods.

Today, more than 30 million people are now growing and eating one or more of the twelve crops biofortified with vitamin A, iron, or zinc, micronutrients identified by the World Health Organization as the most important for health (HarvestPlus, 2018b). Several studies have demonstrated how extra nutrients in crops improve micronutrient status and health in target populations. For consumption of orange sweet potato, a significant increase in body storage of vitamin A across groups might be generated (Haskell et al., 2004; Low et al., 2007; van Jaarsveld et al., 2005). For vitamin A cassava, modest but significant improvement in vitamin status was demonstrated in an efficacy study in eastern Kenya (Talsma et al., 2016). Gannon et al. (2014) showed that after three months, total body storage of vitamin A in children eating orange maize increased significantly compared with those in the control group. Haas (2014) showed improvement in the iron status in Mexican primary school children and Rwandan university women after consuming biofortified beans for 3.5 and 4.5 months, respectively. Islam et al. (2013) and Brnić et al. (2016) found evidence that biofortification of rice is likely as good an intervention as postharvest zinc fortification to tackle zinc deficiency. For wheat with zinc, significantly greater absorption of zinc from biofortified wheat was observed compared to non-biofortified wheat (Rosado et al., 2009; Signorell et al., 2015).

1.2 ACCEPTANCE TOWARDS OF BIOFORTIFIED CROPS

In order for biofortification to be a complementary and efficient strategy to fight micronutrient deficiencies, biofortified crops must be accepted by target producers and consumers. To be successful, any biofortification strategy requires widespread adoption by farmers (Nestel et al., 2006) and acceptance and consumption by malnourished target populations (Birol et al., 2015). Farmers' acceptance towards biofortified crops has been evaluated through different types of studies as farmer field day evaluations, farmer feedback studies, impact assessment studies, and impact evaluation studies. As a result, farmers' acceptance towards various agronomic and consumption attributes of tested biofortified crops, as well as significant rates of adoption and diffusion, were found. In the case of orange sweet potato (OSP), high adoption rates and preferences towards sensory attributes were found in different African countries; information on nutritional benefits played a significant role (Arimond et al., 2010; Chowdhury, 2011). Similar results were found for a product elaborated with vitamin A cassava called *gari* in Nigeria (Oparinde et al., 2016a), a product made with orange maize called *nshima* in Zambia (Meenakshi et al., 2012), and another one named *kenkey* in Ghana also prepared with orange maize (Banerji et al., 2013). In all these cases, nutritional information campaigns were important for driving consumer acceptance towards vitamin A biofortified crops and products.

In the case of iron biofortified crops, in Rwanda, iron bean adopters liked the consumption and production attributes they tested at least as much as the most popular local varieties they normally employed (HarvestPlus, 2017), and nutritional information had a significant positive effect on the premium consumers were willing to pay for the iron bean varieties (Oparinde et al., 2016b). For iron pearl millet grain and a processed product called *bakhri* in India, consumers liked the sensory attributes as much as those of the conventional variety, even in absence of information about nutritional benefits (Banerji et al., 2016). In general, in the case of consumer acceptance studies using sensory evaluation and willingness to pay methodologies, HarvestPlus (2017) found that with or without information about the nutritional benefits of biofortified crops, consumers prefer these over the conventional ones.

1.3 BIOFORTIFIED CROPS AND NUTRITIONAL INFORMATION

Biofortified crops can be classified into two main groups. Those with a visible or observable nutritional trait (i.e., crops like cassava and sweet potato that change color from white/cream to yellow/orange when enriched with vitamin A), and those with invisible or nonvisible traits (i.e. that cannot be observed in plain sight). Crops enriched with minerals, such as iron and zinc, do not change color or have any other change in appearance from biofortification. That is, for example, the case for iron biofortified beans and pearl millet.

Biofortified crops, mainly those with invisible traits, can be treated as *credence goods*. Dulleck et al. (2011) explain that:

> Credence goods have the characteristics that though consumers can observe the utility they derive from the good ex-post, they cannot judge whether the type or quality of the good they have received is the ex-ante needed one. Moreover, consumers may even ex-post be unable to observe which type or quality they actually received. (p. 530)

Some examples of credence goods are health services, legal services, child day care, and religious and spiritual guidance (Benz, 2007). These kinds of goods are characterized by asymmetric information between sellers and consumers that may give rise to inefficiencies, such as market failures (Dulleck et al., 2011).

The provision of information obviously plays an important role for overcoming –at least to some extent– the asymmetric information problem that characterizes credence goods. That is why nutritional information has played a significant role in dissemination strategies of biofortified planting materials to farmers, as well as to food consumers. Several studies evaluating the impact of nutritional information and the media through which such information is conveyed, its length, and content, among others, have been carried out in different Asian and African countries (see for example, Meenakshi et al. (2012) and Banerji et al. (2013) for vitamin A-enriched maize in Zambia and Ghana, respectively; Naico and Lusk (2010) and Chowdhury et al. (2011), for vitamin A-enriched orange sweet potato in Mozambique and Uganda, respectively; Oparinde et al. (2016a, 2016b) for vitamin A-enriched cassava in Nigeria and iron-enriched beans in Rwanda, respectively; and Banerji et al. (2016) for high iron pearl millet in India). The main findings of these studies were summarized in the previous section.

1.4 NUTRITIONAL INFORMATION AND CONSUMER ACCEPTANCE OF BIOFORTIFIED CROPS WITH NO VISIBLE TRAITS

In order to make a decision among similar products or credence goods, information about the products' price and cost may be relatively easy to get, but the detection of product attributes may be more difficult (Benz, 2007). The lack of information about product quality and attributes impacts consumers' decisions and behavior. For this reason, nutritional information plays a relevant role in consumers' acceptance and willingness to pay for biofortified crops with no visible traits as those biofortified with iron or zinc. The impact of this information is likely to depend on various socioeconomic consumer characteristics, such as knowledge and perceptions towards those attributes, and their gender and market participation.

1.5 OBJECTIVES AND RESEARCH QUESTIONS

The first objective of this dissertation is to evaluate the main socioeconomic characteristics that define consumers' preferences for specific biofortified crop attributes. All the consumer acceptance studies carried out so far with biofortified crops have evaluated the relationship between the main socioeconomic characteristics and the crops' acceptance in general, but none have evaluated the relationship between those characteristics and the acceptance for each of the attributes evaluated. The acceptance for some crop attributes, such as taste and time required for cooking, must be gender-oriented; others, such as size, color, and hardness, must be impacted by consumers' market orientation. Further, the acceptance of traits as the time required for cooking and hardness must be associated with consumers' wealth, because of the amount of fuel consumption that is necessary when preparing the crop for consumption. The first major contribution to the literature of this dissertation is to understand how socio-demographic characteristics predict consumers' preferences for organoleptic attributes, such as color, size, and taste. Filling up this research gap on consumer acceptance of biofortified crops will enable a more focused and comprehensive understanding of consumers' preference formation for some attributes that could be modified by the biofortification process or other techniques.

To gain a deeper understanding of the relationship between consumers' socio-demography characteristics and consumers' preference formation is the first step to accomplishing the second objective of this dissertation. With this objective, we seek to analyze the impact of nutritional information and how its interaction with some socioeconomic variables impacts consumer acceptance and willingness to pay for biofortified crops with no visible traits. A differentiation of how nutritional information impacts men and women's acceptance of iron biofortified varieties is expected. For men, health and nutritional factors are hypothesized to be less important when making food choices compared to women (Wardle et al., 2004). Therefore, a higher positive impact of health and nutrition-related factors is expected on women's acceptance and willingness to pay. Araganini et al. (2012) also stated that men usually show resistance to nutritional messages, especially among less educated and wealthier groups. Moreover, we hypothesize that farmers with a strong market orientation will prefer market-oriented attributes, such as size, color, and hardness; meanwhile, those with little market orientation are expected to prefer consumption attributes, such as taste and nutritional content. A deeper understanding of these impacts and how these vary across gender and market participation is still missing in the literature of consumer acceptance of biofortified crops. Thus, this dissertation aims to reduce these research gaps.

The expected results are not only scientifically interesting but useful for a better understanding of the differences in the acceptance of the same biofortified varieties across regions and communities and the determining factors thereof. This information could, therefore, be a valuable input for breeders and dissemination strategy designers. In the same direction, information resulting from this analysis might complement the findings from previous consumer acceptance studies of biofortified crops and help inform the framing of future studies in order to have more accurate results, which could lead to the design of more effective dissemination and promotion strategies.

The two research objectives lead to the following four research questions of this dissertation:

1. What are the impacts of the nutritional information and its repetition on consumer acceptance towards the main organoleptic attributes of an iron bean variety in rural Guatemala, and the willingness to pay for this variety compared with the most popular local variety?
2. Which socioeconomic factors define consumers' attitudes towards an iron biofortified bean variety in rural Guatemala?
3. Which role do gender aspects play on the impact of nutritional information on the acceptance of iron biofortified crops?

4. Do respondents' main roles as consumers or producers and their participation in markets play a significant role in how iron biofortified crops are evaluated?

1.6 EMPIRICAL DATABASE

To address these research issues, two comprehensive surveys including a sensory evaluation and a willingness to pay (WTP) study were carried out in Guatemala. The survey evaluated consumer acceptance of an iron biofortified grain variety called *super chiva* in northwestern Guatemala. The other study evaluated producer acceptance of seeds and grains of the same variety in different regions of the country. Further, a database of a consumer acceptance study of two iron biofortified bean varieties in Rwanda, and another of a consumer acceptance study of an iron pearl millet variety in India were also used.

The first survey on consumer acceptance was carried out in 2013 in the municipality of San Sebastian Huehuetenango, in the Huehuetenango Province, in northwestern Guatemala, along the Mexican border. Huehuetenango is one of the poorest provinces in Guatemala, with high levels of bean consumption and production, and high levels of iron deficiency, which affects over one-third of the children and pregnant women (MSPS, 2012). The region has suitable agroecological conditions for the production of the iron bean variety *super chiva*, as demonstrated by agronomical tests carried out by the Science and Agricultural Technology Institute of Guatemala (Instituto de Ciencia y tecnología Agrícola ICTA). The municipality of San Sebastian was chosen because of its prevalence of chronic malnutrition (72.2%), ranking 27 out of 330 municipalities in Guatemala (Gobierno de Guatemala, 2012), and a lower number of nutrition interventions compared with the other municipalities.

In this study, two black bean varieties were used, one is an iron-enriched bean (IB) variety (*super chiva*) that has 74 ppm of iron, and the other is the traditional local variety (*parramos*) that has 50 ppm of iron and is commonly consumed in the study area. On average, non-biofortified bean varieties have 45 to 55 ppm of iron. Data were collected using the home use testing (HUT) method in which each of the 360 selected households received 1 pound of grain (456 grams) of both bean varieties for two days (one variety each day, selected in random order) to cook and eat at home. Each consumer was encouraged to experience and evaluate the following sensory and cooking attributes: raw bean color, raw bean size, bean taste, cooking time, cooked bean thickness, cooked bean hardiness, and to make an overall evaluation. Each attribute was evaluated on a seven-point Likert scale ranging from 1 (dislike very much) to 7 (like very much). To investigate the role of information repetition of the nutritional value of the iron-enriched bean cultivar, the sample was divided into three treatments. In treatment 1 (control group), none of the respondents received any information about the nutritional benefits of the IB variety tested; in treatment 2, respondents received information on the IB variety on the first day; and in treatment 3, respondents received information on the IB variety three times, once every day. The participants at each location were randomly assigned to one of the three treatments.

The sensory evaluation for the first bean variety was carried out on the second day, and the assessment for the second variety was made on the third day along with an auction-like activity to elicit respondents' willingness to pay (WTP) for both types of beans. Those in the third group received the nutritional information for the third and final time, just before the sensory evaluation and the auction-like activity.

The second study on early acceptance and adoption of an iron bean variety in western and eastern Guatemala was conducted from 2014 to 2015. In this study, Guatemala's Ministry of Agriculture (MAGA) and the Inter-American Institute for Cooperation on Agriculture (IICA) implemented a project in which seeds of the iron bean variety *super chiva* was distributed in 12 departments across Guatemala. In total 1,050 bean producers received seeds in 98 municipalities. Because of the severe drought in the region in 2014, many of these beneficiaries lost their crops. After that, the beneficiaries' sample was reduced to 540 distributed in 8 departments and 98 municipalities. Only 332 of these were surveyed. The distribution of beneficiaries by region was similar, 168 in the western region (Huehuetenango, Quezaltennago, Quiché, and San Marcos) and 164 in the eastern region (Alta Verapaz, Chimaltenango, Jalapa, and Sololá).

The seed was distributed from April to August of 2014. The beneficiaries were interviewed in April 2015. The survey included questions about the beneficiary and their farm, the plots in which the *super chiva* seeds were planted, the bean varieties traditionally planted, their production and usages, their experience plating beans and especially *super chiva*, household socioeconomic characteristics, food intake, and dietary diversity. At the end of the questionnaire, some questions related to their acceptance of sensory, culinary, and agronomic characteristics were asked as well as their willingness to pay for *super chiva* in the market. In this study, participants were directly asked about their WTP for a pound of *super chiva* seed. No elicitation method for WTP was applied here. Because no market for bean seeds exists in Guatemala, the reference used by the respondents was the bean grain's market price.

As in the consumer study, a seven-point Likert scale was used, and the sensory attributes evaluated were the same. The agronomic characteristics tested were yield, crop management, drought resistance, flood resistance, low fertility resistance, pest resistance, diseases resistance, storage, and market acceptance.

In the case of the consumer acceptance studies of two iron bean varieties in Rwanda and one iron pearl millet variety in India, data on consumer evaluation of the main organoleptic attributes of the iron-biofortified crop varieties tested using a hedonic rating method (sensory evaluation) and consumer valuation (WTP) through the Becker-DeGroot-Marschak (BDM) mechanism were collected. In each study, a popular local variety was used as a control. A home use testing (HUT) approach was employed in Rwanda and a central location testing (CLT) approach was used in India (Table 1).

In Rwanda, 579 respondents tested two iron biofortified bean varieties, RWV3316 (red) and RWV3006 (white), and a traditional local variety called Mutiki (red mottled). As in Guatemala, respondents were randomly allocated three treatments: in treatment 1, the control group respondents did not receive any information; in treatment 2, respondents received nutritional information once; and in treatment 3, respondents received information three times. Participants in treatment 2 received the information once on the first day before the sensory evaluation took place. Participants in treatment 3 received the nutritional information three times each day before the sensory evaluation and the BDM mechanism were carried out. Information was delivered using an MP3 device.

In the case of India, 452 respondents took part in this study in which an iron biofortified pearl millet variety (HIPM) was evaluated compared to a local pearl millet variety in two presentations, as grain and as *bhakri* (a thick flatbread). Apart from treatment 1 (control group with no information received) the sample was divided into two treatment groups, each receiving nutritional information through infomercials only once but differentiated by the certification authority, one international and the other national (local). Participants were presented with both cooked and raw grains of the HIPM and Local Pearl Millet (LPM) varieties that were to be tested by each participant, in turn. There were four sessions on the days of the experiment. The first two were treatment 1, and the last two were treatment 2 (infomercial - international authority) and treatment 3 (infomercial - national authority). The order of these sessions was randomized across the 12 locations assessed.

In India, after the demographic and socioeconomic survey, an infomercial was presented. There were two versions of the infomercial containing the same information about the nutritional benefits of HIPM. The infomercial presented to the group in treatment 2 showed the HIPM with the international brand (HarvestPlus) and an international health certification, meanwhile, the infomercial presented to the group in treatment 3 showed the HIPM with a local, state-level brand (Samarth) and a state-level health authority certification. Each group watched the infomercial at the same time on the same TV, always accompanied by the enumerators to ensure they paid attention to the infomercial and did not discuss the information with each other at any time during the period they were watching it.

Table 1 summarizes the main characteristics and results of the hedonic testing and WTP studies previously described, and the others used for this dissertation.

Table 1. Summary of the hedonic testing and WTP studies considered

Study No.	Country	Biofortified food	Sample size (respondents)	Test setting[a]	WTP method[b]	Treatments	Participation fee	Year
1	Guatemala	Iron beans (Grain)	360	HUT-rural	BDM	• Nutritional information heard once • Nutritional information heard three times	Not given- out of pocket payment	2013
2	Guatemala	Iron beans (Seed)	332	HUT- rural	Direct questions	• No treatments • All the respondents received nutritional information once	N/A (WTP was not elicited)	2015
3	Rwanda[c]	Iron beans (grain)	579	HUT - rural	BDM	• Nutritional information: short and positive • Nutritional information: short, positive, and endorsed • Nutritional information: long and positive • Nutritional information: long, positive, and endorsed	Not given- out of pocket payment	2013
4	India	Iron pearl millet (*bakhri*)	452	CLT-rural	BDM	• Nutritional information and State level certification branding • Nutritional information and private certification and branding	Not given- out of pocket payment	2012

Source: Adapted by authors from Birol et al. (2015)

[a] Test setting: CLT Central Location Testing; HUT Home Use Testing

[b] WTP Willingness To Pay method: BDM Becker-DeGroot-Marschak auction mechanism

[c] Only the sample corresponding to Gakenke, in the northern Province of Rwanda, was used (579 respondents)

1.7 STRUCTURE OF THE DISSERTATION

This dissertation contains four papers that have been published or are under review by peer-reviewed scientific journals. Each paper addresses one of the four main research questions of this dissertation.

The first article is based on Chapter 2, entitled “Consumer acceptance of an iron bean variety in northwestern Guatemala: The role of information and repeated messaging”, analyzes the acceptance of different organoleptic attributes and the willingness to pay for an iron biofortified bean variety. The impact of receiving information regarding the nutritional characteristics and benefits of the biofortified variety and its repetition on the valuation of the attributes tested and the acceptance of the crop, in general, was evaluated. This is the first analysis of its kind carried out in Latin America. Further, it seeks to inform policy makers and managers in the region about which strategy will increase the acceptance of biofortified crops. The study investigates the impact of nutritional information and targets consumers’ main characteristics (gender, education level, among others) on the acceptance of an iron bean variety.

The second research article includes the information contained in Chapter 3 and is entitled “Identifying socioeconomic characteristics defining consumers’ acceptance for main organoleptic attributes of an iron-biofortified bean variety in Guatemala”. Based on an extensive literature review, it appears that this is the first time that the socio-demographic characteristics predicting consumers’ preferences for main sensory attributes of an iron-biofortified bean variety are analyzed. According to consumer behavior economics, socioeconomic, cultural, and biological characteristics define consumer preferences for specific product attributes. In the case of the iron-biofortified bean variety in Guatemala, consumers revealed that preferences are mostly related to bean production status and market orientation of the respondents. In this case, nutritional information does not play any role in the acceptance of any of the sensory attributes tested, but its repetition does, mainly when it is given to men.

The third article based on Chapter 4 entitled “The impact of nutritional information on consumer acceptance of nutritious foods: A gendered analysis of iron-biofortified foods in India, Guatemala, and Rwanda”, shows a gendered analysis of consumer acceptance for iron biofortified crops. To our knowledge, this is the first time that the joint role of nutritional information and gender is directly evaluated in a consumer acceptance study of a biofortified crop. According to different authors, men are less interested in health-promoting behaviors and healthier lifestyle patterns, so nutritional information is expected to have a lesser impact on men's acceptance of the iron biofortified varieties tested, mainly in less educated and wealthier groups. Understanding the gender differences on how nutritional information can impact consumer acceptance towards biofortified crops is essential to potentiate the impact of biofortification. A promotion strategy of a biofortified variety based on nutritional information addressed to women could be more cost-effective than one addressed to men, as women are generally the primary caretakers of children and they influence food purchase decisions and intra-household food distribution.

The fourth article including the information comprised in Chapter 5 is entitled "Role of respondent's market participation on consumer acceptance towards seeds and grains of an iron bean variety" evaluates how respondents' role as producers or consumers and their market participation affects their acceptance differently depending on the testing of seeds or grains. A consumer acceptance study testing grain and another testing seed of an iron-biofortified bean variety in Guatemala were used for this purpose. It should be noted that all consumer acceptance works of iron biofortified varieties have used grains, regardless of whether respondents are only consumers or also producers. Most of the biofortification target populations are farmers who produce and consume one or more staple crops in significant quantities. Biofortified crops are bred to display nutritional and agronomic attributes, but when respondents only evaluate grains, those agronomic attributes are not tested. More accurate results might be obtained if those consumers who produce their own food could test the seed and consume the grain harvested. Such results would be highly related to respondents' market participation; those with high market participation will value the variety attributes based on market preferences, and those with low market participation will do so based on their individual and family preferences.

Lastly, Chapter 6 summarizes the methodological contributions and provides conclusions. Broader research and policy implications are discussed.

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2. CONSUMER ACCEPTANCE OF AN IRON BEAN VARIETY IN NORTHWEST GUATEMALA: THE ROLE OF INFORMATION AND REPEATED MESSAGING

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The article in this chapter is published on *Agricultural and Food Economics,* Volume 14, Issue 6. It was originally submitted on July 18^{h}, 2017, re-submitted for review on September 12th 2017, and accepted on July 9th, 2018 for publication.

ABSTRACT

Micronutrient malnutrition affects 2 billion people worldwide and biofortification could prove to be a cost-effective solution to its alleviation. The aims of this study are: (i) to understand consumer acceptance of the main sensory characteristics such as taste, color, texture, etc., of an iron-enriched bean variety compared to a popular traditional one ('parramos'); (ii) to measure consumer willingness to pay (WTP) for an iron-enriched bean variety compared to a traditional one; (iii) to investigate the role of nutritional information; and (iv) to understand the impact of information repetition on consumer acceptance. To achieve this, a home use testing (HUT) method and a Becker-DeGroot-Marschak mechanism were used. The results indicate that consumers equally preferred the iron-enriched and the local bean varieties, although some minor differences were found in some of the sensory characteristics. Although the mean WTP for the iron-enriched bean variety was higher, the difference was not statistically significant among the groups evaluated. The information provided and the order of variety delivery play a significant role in consumer acceptance for the iron-enriched variety, and repetition in providing information had a positive impact depending on the type of message provided and on who received it (e.g. men or women, more educated respondents). Potential censored bids were found due to the nature of the currency interval and some transaction costs.

Keywords: Consumer acceptance, willingness to pay, iron-enriched bean, nutritional information, Guatemala

2.1 INTRODUCTION

Micronutrient malnutrition, or hidden hunger, affects 2 billion people worldwide. One potential solution to its alleviation is biofortification, i.e. the process of breeding and delivering staple food crops with higher micronutrient content. Biofortified varieties and traditional varieties differ in their micronutrient content while their color, size, texture, and other organoleptic and agronomic attributes are usually similar. Varieties with higher carotenoid content may differ in color, i.e. they are often more yellow. Biofortification could prove to be a cost effective and sustainable strategy, especially in the rural areas of many developing countries where there is high production and consumption of staple crops and where micronutrient deficiency rates are high (Meenakshi et al., 2012; Saltzman et al., 2013). In recent years, several bean, rice and maize varieties with higher micronutrient levels were released in various Latin American and Caribbean (LAC) countries. Moreover, many promising new varieties with even higher levels of micronutrients are in the pipeline for release. Biofortification is increasingly gaining momentum in LAC with some countries such as Brazil and Panama, including them in their public regulations and many others such as Colombia and Honduras considering it as an alternative intervention to strengthen their efforts against micronutrient malnutrition, particularly in rural areas. Despite all these efforts and the improved momentum, there has been relatively little research on evaluating consumer preferences for, and acceptability of, these biofortified varieties by target populations in the region.

Guatemala is one of the LAC countries with the highest proportion of population living in rural areas. Most rural Guatemalans are indigenous and have a deep-rooted bean consumption tradition. An average Guatemalan consumes 34 g of beans per day (INE, 2006). According to the Micronutrients National Survey carried out by the Ministry of Public Health and Social Assistance (MSPS) between 2009 and 2010, iron deficiency was an important public health problem, as 24% of the children and 20% of the women in rural areas do not receive sufficient iron in their diets. In general, iron deficiency in rural areas is slightly higher in indigenous communities than in non-indigenous ones (‘mestizos’). Given the high bean consumption and high iron deficiency rates especially in rural areas, biofortifying beans with iron could be a promising solution to reduce iron deficiency prevalence in Guatemala.

The success of biofortification depends on whether biofortified foods are accepted and consumed by target populations (Meenakshi et al., 2012). Acceptance depends on consumer preferences for various organoleptic characteristics (e.g. taste, color or texture), as well as their relative price perceptions for biofortified foods. This study contributes to the evaluation of consumer preferences for and acceptance of biofortified foods in the Latin American context. In this study we use similar methods to those used in the African and Asian contexts (see Naico and Lusk, 2010; Chowdhury et al., 2011; Meenakshi et al., 2012, Banerji et al., 2013; Oparinde et al., 2016a, Oparinde et al., 2016b), allowing the comparison of biofortified food acceptance results across regions.

Several studies have been conducted in developing countries to investigate consumer acceptance of biofortified foods and the role of information on the nutritional benefits of such foods in driving demand (see for example, Meenakshi et al., 2012 and Banerji et al., 2013 for vitamin A- enriched maize in Zambia and Ghana, respectively; Naico and Lusk, 2010 and Chowdhury et al., 2011, for vitamin A-enriched orange sweet potato in Mozambique and Uganda, respectively; Oparinde et al., 2016a for vitamin A-enriched cassava in Nigeria; and Banerji et al., 2015 for iron-enriched pearl millet in India). According to Meenakshi et al., (2012), the impact of information on acceptability that has been studied in the literature is complex to interpret as successful nutrition messaging often requires the repetition of messages.

This study aims to examine Guatemalan consumers' preferences for an iron-enriched bean variety (IB variety) known as 'super chiva' (74 ppm of iron) compared to the most popular local bean variety known as 'parramos' (50 ppm of iron). The aims of this study are: (i) to understand consumer acceptance of the main organoleptic characteristics of an iron-enriched bean variety compared to the traditional one using a sensory evaluation (hedonic scores); (ii) to measure consumer willingness to pay (WTP), i.e., the price premium/discount for the IB variety compared to the local one, and the variation of this premium/discount with consumer-specific socioeconomic characteristics; (iii) to investigate whether nutritional information has an impact on driving demand for biofortified foods in the Latin American (i.e. Guatemalan) context, as has been shown in Africa and Asia; and iv) to understand the impact of the frequency with which information is given on consumer acceptance.

The following section presents the details of the selection criteria for the study site, the sampling design, the elicitation and data collection methods, the information, models, survey, tools and analyses used. Section 3 describes and summarizes the main results obtained and Section 4 contains a short discussion and the conclusions, including some policy recommendations.

2.2 MATERIALS AND METHODS

2.2.1 Study site

The data collection was conducted in August 2013 in San Sebastian Huehuetenango municipality, in Huehuetenango province, in northwest Guatemala near the Mexican border. The prevalence of chronic malnutrition in this municipality is 72.2% and it ranks 27 out of 330 municipalities in Guatemala (Gobierno de Guatemala, 2012). Huehuetenango was selected as the study site because of its high levels of bean consumption and production, and high levels of iron deficiency which affects over one-third of children and pregnant women (MSPS, 2012). Moreover, it had suitable agro-ecological conditions for production of the 'super chiva' variety, as demonstrated by agronomical tests carried out by the Science and Agricultural Technology Institute of Guatemala (ICTA).

2.2.2 Sampling design

Power calculations were conducted to determine a statistical significant number of respondents that should be surveyed in this study.

Bean prices in northwest Guatemala vary according to bean color. Red and white bean varieties are the most expensive and are usually consumed on special occasions, while black varieties, which are consumed daily, are the cheapest. In July 2013, the average market price for the traditional black bean varieties was 5 Quetzals[1] per pound.[2] Based on previous studies (Chowdhury et al., 2011; Meenakshi et al., 2012; Banerji et al., 2013), a 15% effect on WTP was anticipated, corresponding to 0.5 Quetzals with a standard deviation of 2.5 Quetzals. Using a significance level of 5% and a power of 0.8, a sample size of 120 households (HH) per treatment (3 treatments) was estimated.

The sampling strategy established a minimum sample size of 360 households from different communities in the San Sebastian Huehuetenango municipality. But as there was no reliable

[1] 1 USD = 7.67 Quetzales. July 2013
[2] 1 pound (lb) = 0.46 kg

secondary data (from any recent census) or any official information on population numbers in the municipality available, the study asked local experts and community leaders in the study site to provide an estimate of the population numbers in each community.

The data collection took place before the harvesting season and coincided with the rainy season, which meant that transportation of the enumerators' teams to some communities was difficult, if not impossible. More remote communities had higher security risks and their members were more reluctant to participate in any kind of study. As a result, a list of 20 accessible and less remote communities was drawn up, and 12 communities were randomly chosen from this list. The number of participating households per community was determined according to the relative proportion of the population among the listed communities. The enumerators selected every fifth household on the list in those communities with 250 or less households, or every seventh household on the list in those communities with more than 250 households; selection was proportional to the community's size. As a result, we obtained a self-weighing sample of households, which represented the safer and less remote parts of the municipality of San Sebastian Huehuetenango.

2.2.3 Data collection

In this study, two black bean varieties were used, one was an iron-enriched bean (IB) variety ('super chiva') that has 74 ppm of iron, and the other one was the traditional local variety ('parramos') that has 50 ppm of iron and is commonly consumed in the study area. The IB variety used in this study was procured from Instituto de Ciencia y Tecnología Agrícola (ICTA) (Spanish acronym) which had been cultivated in the first season of 2013, whereas the traditional variety was obtained from a local farmer who had produced it in the same season.

Data was collected using the home use testing (HUT) method in which a selected household received 1 pound of grain of both bean varieties for two days (one variety on each day, selected in random order) to cook and eat at home. A total of 1 pound of beans was deemed to be sufficient for an average household's breakfast and lunch consumption based on the average household size and demographics and information on the bean quantity consumed per person in the region. Each consumer were encouraged to experience and evaluate the following sensory and cooking attributes: raw bean color, raw bean size, bean taste, cooking time, cooked bean thickness, cooked bean toughness, and the overall evaluation. Each attribute was evaluated on a 7-point Likert scale ranging from: 1 (dislike very much) to 7 (like very much); other levels were 2: dislike, 3: dislike a little, 4: neither like nor dislike, 5: like a little, 6: like. To investigate the role of information repetition on the nutritional value of the iron-enriched bean cultivar, the sample was divided into three treatments. In the first treatment (control group), none of the respondents received any information about the nutritional benefits of the IB variety tested; in the second one, respondents received information on the IB variety on the first day; and in the third group, they received the information on the IB variety three times, once on each day. The participants at each location were randomly assigned to one of the three treatments.

Before describing the study and asking the participants' consent to participate, subjects were asked about their knowledge of IB varieties. To avoid biasing the results, those who stated any kind of knowledge were not invited to join this study (and the next fifth or seventh household on the list was selected instead). Household members who were responsible for food purchasing and cooking (one per household) were asked to participate in this study.

To prevent further nutritional information contamination, the control group (who did not receive any information) was dealt with first (during the first week), and the other two information treatments were completed in the following two weeks. Although we tried to minimize information contamination, there may have been some across-treatment contamination in the Becker-DeGroot-Marschak (BDM) auction-like mechanism and payment requests for the bean varieties evaluated (Oparinde et al., 2016c).

The data collection flow from each household was as follows:

Day 1 (early afternoon): The household randomly received 1 pound of one of the bean samples. The respondents were asked to cook the sample using their usual cooking practices and were told to avoid mixing the bean sample with any other bean variety they may already have had at home. Households were visited early in the afternoon, because they usually cooked their beans in the evening to consume at breakfast and lunch the following day. Each household was given one day to cook and consume the bean variety. One day was thought to be a sufficient amount of time for the households to form an opinion about the variety, while reducing the risk of information contamination through social networks. Households were then visited in the afternoon and they were asked for a follow-up appointment on the next day in the afternoon. The follow-up appointment was set for after lunch to minimize the recall bias of the organoleptic characteristics of the bean varieties. On day 1, those in treatments 2 and 3 received the nutritional message for the first time just before they received the bean sample.

Day 2 (after lunch): On the next day, the enumerator visited the same household to conduct the sensory evaluation of the variety delivered the day before and to give the sample of the second variety. Respondents on treatment 3 received the nutritional information for a second time after they had done the sensory evaluation for the first bean sample.

Day 3 (after lunch): The sensory evaluation for the second sample was carried out on the third day along with the BDM auction-like mechanism for the elicitation of respondent WTP for both types of beans evaluated. Those in treatment 3 received the nutritional information for the third and last time just before the sensory evaluation and the BDM auction-like mechanism were carried out.

The incentive-compatible BDM was chosen due its suitability in rural settings (Banerji et al., 2013) and its applicability for individuals, as it does not require a group of subjects (Lusk and Shogren, 2007). According to De Groote et al., (2011), the BDM mechanism is a much faster and efficient method than other experimental auctions, especially in a rural context. In preference elicitation studies, a participation fee is commonly given to the participants at the beginning of the experiment to avoid participants from being out-of-pocket when making purchases. However, standard economic theory suggests that initial endowments can distort optimal bidding behavior (Corrigan and Rousu, 2006) and empirical evidence shows mixed results (Loureiro et al., 2003; Morawetz et al., 2011; Banerji et al., 2013). In this study we did not include participation fees to avoid such biases and to make the experiment as real as possible. Participants were told that they would be paying out their own pockets for beans if they "won" either one of the bean varieties in the auction-like mechanism.

Enumerators explained to the participants how the BDM mechanism worked. They explained that bidding a higher price than their real WTP could result in them paying a higher price than the one they were originally willing to pay, whereas biding a lower price than their real WTP could result in them losing out on a profitable opportunity to purchase a desired product. Following this explanation, and after ensuring that the respondents understood the workings of the BDM mechanism, the respondent was asked to state a bid for each variety and these bids were written down by the enumerators. After the bidding, the respondent picked one of the two varieties (by picking a slip of paper from a bag containing two slips, each labeled with a different geometric figure). The triangle represented the iron-enriched bean variety and the square represented the local variety but the researchers were the only people who knew this. This selection determined the variety the respondent might end up purchasing. After picking the variety, the respondent picked another slip of paper from a second bag which had 16 slips with prices, ranging from 3.25 Quetzals (Q.3.25) to 7 Quetzals (Q.7), with 0.25 Quetzals (Q. 0.25) intervals. Respondents were previously informed about this range. This was the uniform distribution of potential market sale prices that the subject was competing against. It was explained to respondents that if the price picked from this random draw was lower than their initial bid for the bean variety (also randomly picked from the first bag), the respondent could purchase 1 pound of that variety, making an out-of-pocket payment for a price equal to the competing bid. Otherwise, the respondent could not make a purchase.

2.2.4 Survey and other tools

A lengthy survey was designed in collaboration with local experts and was pretested prior to the data collection. It was divided into three parts and each part was completed during one of the three visits. In treatment arms, the information about nutrition and other characteristics of the iron-enriched bean variety were given through a recorded (simulated) radio message, which the respondents listened to on individual MP3 devices (see Appendix 1 for the content of this message). Qualitative background studies and literature reviews suggest that a simulated radio message would be the most effective information transmitting mean in the rural Guatemalan context, in which illiteracy rate is traditionally high, especially in indigenous communities, and radio ownership and usage is close to 90% (Avila, 2010). This message on nutrition was recorded in Spanish, using local vocabulary and phrases, and the content of the message was developed and validated by nutritionists and by local leaders. This message included topics related to the agronomic and nutritional characteristics of the IB variety and its potential benefits for children and women’s health.

2.2.5 Ethics committee approval and informed consent

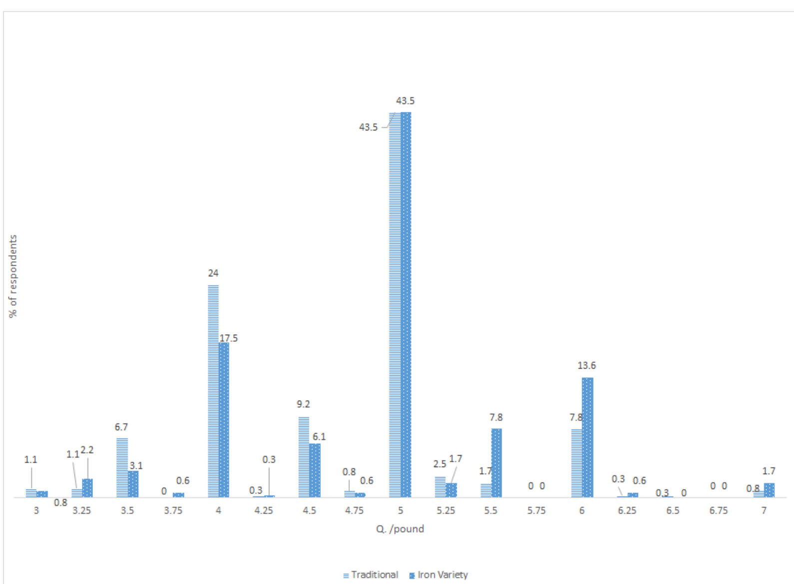
This study was approved by the National Committee of Ethics in Health of the Ministry of Public Health and Social Assistant of Guatemala by Resolution No. 37-13 of May 28/2013.

Informed consent: “Informed consent was obtained from all individual participants included in the study.”

2.2.6 Willingness to pay and premium/discount for iron-enriched bean variety

Figure 2.1 shows the frequency distribution of the WTP for the traditional and the IB bean varieties. For both varieties, almost half (43.5%) of the bids were the same as the average observed market price of beans during the survey (5Q./pound). Bids below 5Q, comprised 43% and 31.2% of the bids for the traditional and the iron-enriched varieties, respectively. Furthermore, bids greater than 5Q. comprised 13.4% and 25.3% of the bids for the traditional and the iron-enriched varieties, respectively.

Figure 2.1 WTP frequency (%) for the traditional and the iron-enriched bean varieties (Q./pound) across treatments



Source: Author’s creation

Based on these results, the WTP data can be grouped as follows:

1. WTP_local = 5 Q.; WTP_iron = 5 Q. (15.60%)
2. WTP_local = 5Q and WTP_iron ≠ 5 Q. (28.13%)
3. WTP_local ≠ 5Q and WTP_iron = 5Q. (28.13%)
4. WTP_local ≠ 5Q and WTP_iron ≠ 5 Q. (28.41%)

For the 15.6% of respondents in which their bids for both varieties equal 5Q, we can assume that their bids may be censored i.e. influenced by the price of outside markets. Those stating prices equal to the market price (5 Q.) may have had higher WTP due to the perceived transaction costs of obtaining the same product outside the auction but bid the price at which they could buy a product in the market (Banerji et al., 2013) Another reason why bids submitted by the 15.6% of the respondents could be censored is the nature of the currency interval. The data show that most of the bids were in currency bounds where the majority ranges from 4.5 Q to 5.5 Q. As a result, participants' bids could bind between the currency intervals. Therefore, for those who stated 5Q for both varieties, we can assumed that there bids were interval censored where the lower and upper bounds of WTP were observed instead of the real WTP, such that WTP can be left and/or right censored (Oparinde et al., 2016c).Thus right and interval censored models were estimated. The Akaike Information Criteria (AIC) was used to compare both models. The model with the smaller AIC fit the data better than the one with larger AIC (Burnham and Anderson, 2002).

Censoring is a feature of the data collection mechanism (Greene, 2006) that allows the identification of potential socioeconomic factors generating respondents' censored bids for both varieties.

As the aim of this study was to measure the premium/discount for the IB variety compared with the local one, this was computed as the difference between WTP for the iron-enriched variety and WTP for the local variety (Equation 1).

$PREM_{i,BL} = WTP_{i,B} - WTP_{i,L}$ (1)

Where:

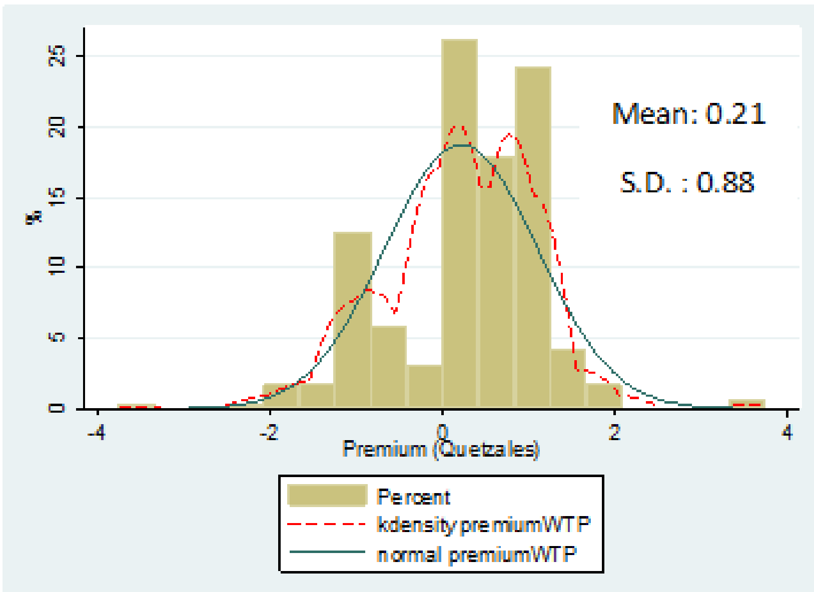
$PREM_{i,BT}$ = the local — The WTP a premium of respondent i for the iron-enriched variety (B) compared to variety (L)

$WTP_{i,B}$ = The WTP of respondent i for the iron-enriched variety (B)

$WTP_{i,L}$ = The WTP of respondent i for the traditional variety (L)

Figure 2.2 shows the distribution of differences in WTP for one 1 lb of iron-enriched bean variety in Quetzals (Q.) compared to the local bean variety or WTP premium.

Figure 2.2 Distribution of differences in WTP premium for 1 pound of the IB bean variety



Source: Author's creation

As we already know the group into which the WTP premiums fall, but we do not know their real value due the potential censored value of some of the WTP bids, either for one of the varieties or for both, then an interval censored regression model applies in order to determine the socioeconomic factors affecting the WTP premium.

The interval censored model states that the probability that the true WTP PREMIUM of a respondent, with characteristics Y lies in the interval [$PREM_L$, $PREM_U$] is given by $\phi(PREM_U|Y)$ - ϕ $\phi(PREM_L|Y)$, where PREM is assumed to follow a distribution with a standard normal cumulative distribution function (ϕ). As the WTP premium is censored because of the WTP censoring, the lower and upper bounds were defined according to WTP premium data. Lower bounds range from -2 to -0.001 and the upper bound from 0 to 2.

In order to include in the analysis any potential differences in the intervention that could impact on the results (e.g. how the enumerator explained the BDM game, interview time, or any other effect of the repetition process), a random effect model of WTP premium was also estimated. As we have a relatively high number of individuals, we considered the individual differences as random disturbances (equation 2) drawn from a specified distribution, including the regressor (ρ):

$$\mathrm{PREMi, bt} \;=\; \alpha + \; x\beta + \rho i + \varepsilon t \qquad (2)$$

A Hausman and a Breusch-Pagan Lagrange multiplier (LM) test was run to give more support to the random effect model estimation.

To check the robustness of the random effects absolute WTP premium model and the interval censored WTP premium model, an ordinary least square model (OLS) was also estimated (Appendix II).

2.2.7 Independent variables

Based on previous studies that analyzed consumer acceptance for biofortified crops and the role information played, the following independent variables were included in the models (Table 3.1).

Table 2.1 Independent variables included in the models estimated

Variables	***Description***
Treatment 2 (information once)	= 1 respondent was in Treatment 2; 0 otherwise.
Treatment 3 (Information three times)	= 1 respondent was in Treatment 3; 0 otherwise.
Variety order	= 1 if iron variety was received first; 0 otherwise.
Gender	= 1; respondent is male; 0 otherwise.
Age	Continuous variable indicating the age of the respondent.
Education	Categorical variable indicating respondents' education level.
Area planted in 2013	Square meters planted in total in the farm in 2013.
The household is a bean producer	Dummy variable indicating that the respondent plants beans every year.
The Progress out of Poverty index (PPI)	Grameen Foundation's Progress out of Poverty index (PPI) accounts for head of HH's education, HH assets and income (calculated by the authors with survey data, explained below).
Quantity of bean grain at home	Continuous variable indicating the quantity of bean grain at home at the time of the visit.
Monthly expenses	Average HH monthly expenses.
Number of people met	Continuous variable indicating the number of people met in the community in the last three days.
Hear Iron food	Dummy variable indicating if the respondent had heard about iron in food.
Food Frequency Index (FFI)	Food Frequency Index, explained below.

Source: Author's creation

2.2.8 The progress out of poverty index (PPI)

The PPI is a poverty measurement tool developed by the Grameen Foundation. It is computed by using the answer to 10 questions about household characteristics and asset ownership, to determine the likelihood that the household is living below the poverty line (US$ 1.25 / day (2005 PPP)).

The PPI is country specific (Grameen Foundation, 2015). There is a set of 10 specific questions for 45 countries. In this study, country specific questions for Guatemala were asked. The higher the PPI, the likelihood of a household to be under the poverty line is lower.

2.2.9 Food frequency index (FFI)

A FFI was constructed following Arimond and Ruel (2002) with data collected on 15 food groups for a seven-day recall period. Respondents were first asked if they had consumed the food group in the last 7 days, and if yes, how many days in the last 7 days they consumed the food. For each food group, a household or individual receives a score of 0 for frequencies lower than four days per week, a score of unity for frequencies from four to six (inclusive) days per week, and a score of two for frequencies of seven or more. The diversity count is then summed across food groups (Smale et al., 2013). With 15 groups, the range of this indicator is considerably big (1 to 30), whereas the maximum FFI in the data is 19.

2.2.10 Information retention index (IRI)

This index is built and assesses how much of the information received was actually retained by the respondents. A set of questions relating to anemia and iron deficiency were asked the first day to all respondents before the radio message was heard by those in treatments 2 and 3. On day 3, the same set of questions was asked to those who received information once or thrice. One index is built for pre–information, and another one for the post-information given.

Each index was constructed using four questions highly related to the information provided in the radio message:

1. Have you heard of anemia before now? Yes=1, No = 0
2. One of the most important symptoms/consequences of anemia is fatigue? Yes=1, No=0
3. One of the most important symptoms/consequences of anemia is stunting? Yes=1, No=0
4. Have you heard about iron-enriched food? Yes=1, No = 0

The information retention index (IRI) was estimated as follows:

$IRI = II_2 - II_1$

Where the pre-information index (II_1) was estimated by adding the different scores obtained in each responses for the former questions during the first day (max=4, min=0); and in the same way the post-information index (II_2) was estimated using the responses given to the same questions in day 3.

Then:

IRI =0 if the anemia and iron deficiency knowledge stock does not change from day one till day three.

IRI >0 if the anemia and iron deficiency knowledge stock increases from day 1 up to day 3.

For those in treatment 1 who did not receive any information, the IRI is considered to be 0, because any change in their stock of knowledge is not expected as they did not receive any information. Respondents in this treatment were surveyed during the first week, and those receiving information were surveyed during the following two weeks to avoid information contamination from respondents who received information in the treatments to the ones in the control group; however, some potential contamination can be expected from control to treatments.

2.2.11 Interaction variables

To analyze the role that gender and educational aspects had on how information affected consumer acceptance, the interaction between the treatment variables, gender and education were included. Interaction with males (male x treatment 2, and male x treatment 3) examined any gender implication and the possible effect of information and repetition on consumer acceptance for the iron-enriched varieties for men and women was also examined, i.e. it is possible that women were more susceptible to nutritional information than men were. The interaction of these treatment variables with education was also included (education a treatment 2 and educationatreatment 3). It was expected that those with higher education would show a stronger effect. Moreover, the effect of the order in which the bean variety was given to respondents was also included. It was expected that those respondents who received information and the iron-enriched bean variety on the second day were willing to pay a higher price for the iron-enriched variety because they had new information in their heads about the benefits of iron-enriched beans.

2.3 RESULTS

2.3.1 Descriptive statistics

Table 3.2 presents the key socioeconomic characteristics of the respondents and their households, by treatment arm, and the results of the ANOVA analysis for median homogeneity across the three groups. A pairwise comparison was also carried out using Tukey test to compare the median differences of these characteristics between treatments (Treatment 1 vs Treatment 2, Treatment 1 vs Treatment 3, and Treatment 2 vs Treatment 3). The key socioeconomic characteristics listed were those that were hypothesized to affect respondent WTP.

Most of the key participants and households' social and economic characteristics were similar across treatments, revealing that randomization in treatment arms worked well. Statistical differences were observed for gender between all treatments, in the number of members per household and in the percentage of households with children between 1 to 5 years between all treatments according to the Information Retention Index.

Variables such as initial knowledge about iron deficiency and anemia, and the quantity of bean they had at home were not significantly different across treatments, showing similar iron deficiency and anemia awareness endowment, and levels of product ownership among groups. Information from the National Agricultural Research System (NARS) variable was similar across treatments as well. Similarly, there were no significant differences in the results of the BDM mechanism across treatments. Moreover, 45% of the respondents "won" in the BDM experiment. Among the "winners", 7.7% did not want to pay and 10.2% were unable to pay. On average 15.2% of those who won and did not pay stated lack of money as their reason for not paying; this proportion was also statistically similar across treatments. These results are similar to those found in other studies; Oparinde et al. (2016b) stated that 13% of subjects could be expected to be unable to pay out of pocket when conducting auction experiments in developing countries. The inability to make an out-of-pocket payment was correlated with a country's wealth levels, but it varied significantly across countries.

Table 2.2 Social and economic characteristics by treatment group (ANOVA test and pairwise comparison)

Variable	Definition	Mean (S.D.) Treatment 1 (no information) N=120	Treatment 2 (information once) N=120	Treatment 3 (information three times) N=119	Prob > F	Tukey P> t T1 vs T2 T1 vs T3 T2 vs T3
Age	Respondent's age (in years)	36.24 (11.40)	35.82 (11.41)	34.96 (34.96)	0.73	0.33 0.50 0.18
Male[a]	1 if respondent's gender is male, 0 otherwise	45.46%	23.01%	37.23%	0.00	0.00 [c] 0.08 [a] 0.03[b]
Literate	1 if respondent knows how to read and write	78.03%	76.25%	73.00%	0.77	0.21 0.37 0.15
Household size[b]	Number of HH members	6.32 (2.53)	6.06 (2.67)	5.46 (2.10)	0.02	0.33 0.12 0.06 [a]
Monthly expenditure	Total expenditures in the last 30 days (in Quetzals)	2,447 (1,217)	2,629 (2,179)	2,265 (1,071)	0.20	0.19 0.17 0.31
The Progress out of Poverty index (PPI)	HH Poverty level according to Grameen Foundation Index	60.93%	66.47%	65.45%	0.31	0.44 0.27 0.13
Food Frequency Index (FFI)	Counting of 15 food groups consumed in the last 7 days (less than 4=0, 4–6=1, 7+=2)	6.34 (3.19)	5.90 (2.44)	5.93 (2.57)	0.39	0.15 0.19 0.20
Infants under 12 months	% HHs with infants less than 12 months old	22.51%	25.01%	20.34%	0.40	0.13 0.21 0.16

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level.

Table 2.3 (*Cont.*) Social and economic characteristics by treatment group (ANOVA test and pairwise comparison)

Variable	**Definition**	**Mean (S.D.)**			**Prob > F**	**Tukey P> t** T1 vs T2 T1 vs T3 T2 vs T3
		Treatment 1 (no information) N=120	**Treatment 2 (information once) N=120**	**Treatment 3 (information three times) N=119**		
Children between 1–5 years old[c]	% HHs with children between 1-5 years	53.32%	40.03%	45.20%	0.06	0.00 [c] 0.07 [a] 0.02 [b]
Quantity of beans at home	Quantity of beans at home when the first sample was delivered (pounds)	405.95 (486.34)	326.54 (460.39)	343.85 (468.32)	0.39	0.14 0.14 0.11
Anemia knowledge	Index describing anemia knowledge (min= 0, max=12)	3.48 (3.06)	3.56 (3.54)	3.76 (3.69)	0.81	0.18 0.22 0.35
Information Retention Index[c]	Information Retention Index (min=0, max=4)	0 (0)	0.991 (0.78)	1.252 (1.03)	0.00	0.01 [c] 0.00 [c] 0.09 [a]
Winner	1 if participant won	39.10%	49.12%	47.02%	0.26	0.20 0.15 0.11
Won and paid (% of those who paid among winners)	1 if participant won and paid	63.89%	52.56%	64.31%	0.23	0.12 0.11 0.23
Won and did not pay (% of those who did not pay among winners)	1 if participant won and did not pay	17.02%%	23.72%	10.70%	0.17	0.19 0.12 0.27
Won and could not pay (% of those who couldn't pay among winners)	1 if participant won and could not pay	19.13%	23.72%	25.01%	0.27	0.19 0.23 0.12
% of those who stated no money as reason for no pay	1 if lack of money was the main reason for no payment	9.40%	10.92%	10.92%	0.14	0.11 0.15 0.11

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance lev

Source: Author's estimation

2.3.2 Sensory evaluation

Table 3.3 shows the frequency of hedonic ratings of the sensory attributes of the two bean varieties. According to the results of the sensory evaluation, participants scored both varieties above 6 (80% or more). These results were similar for both varieties in all three treatments and were marginally higher for the iron-enriched variety for all the characteristics evaluated except for cooked bean toughness in treatments 2 and 3. For Treatment 1, the liking scores distribution was statistically different between the traditional and iron-enriched variety in the case of taste, showing that for an iron-enriched variety almost all of the respondents were in groups 6 and 7. For Treatment 2, the liking distribution was statistically different for color, size and the overall evaluation, while for Treatment 3 taste and toughness were the only two attributes that showed any differences between the two varieties. In all these cases, a higher proportion of respondents were grouped in 6 and 7 scale for the iron-enriched variety compared to the traditional one.

Table 2.4 Frequency of respond for hedonic rating for bean varieties (home testing, northwest Guatemala) (hedonic score/%)

	Bean variety	*Raw bean color*	*Raw bean size*	*Bean taste*	*Cooking time*	*Cooked bean thickness*	*Cooked bean toughness*	*Overall*
Control (T1): No information presented	Local	7 60.83% 6 34.17% 5 5.00%	7 65.83% 6 48.33% 5 5.00% 2 0.83%	7 70.83% 6 22.50% 5 5.00% 2 1.67%	7 49.17% 6 36.67% 5 6.67% 3 3.33% 2 4.17%	7 52.50% 6 34.17% 5 9.17% 3 2.50% 2 1.67%	7 58.5% 6 37.6% 5 3.90%	7 64.17% 6 29.17% 5 4.17% 4 0.83% 3 1.66%
	IB	7 72.50% 6 21.67% 5 4.17% 3 1.67%	7 69.17% 6 25.83% 5 3.33% 4 0.83%	7 81.67% 6 16.67% 5 1.67%	7 68.33% 6 25.00% 5 5.00% 3 1.67%	7 75.00% 6 18.33% 5 5.83% 3 0.83%	7 70.00% 6. 19.65% 5 7.33% 4 3.02%	7 77.50% 6 20.00% 5 1.67% 4 0.83%
	Difference in distribution							
	Pearson Chi-square (p-value)	0.17	0.12	0.08 [a]	0.23	0.13	0.06	0.33
T2: Information presented once	Local	7 59.17% 6 36.67% 5 3.33% 3 0.83%	7 53.33% 6 43.33% 5 3.33%	7 65.00% 6 33.33% 5 1.67%	7 60.00% 6 30.00% 5 6.67% 3 2.50% 2 0.83%	7 55.83% 6 38.33% 5 4.17% 3 1.67%	7 61.25% 6 37.44% 5 1.31%	7 64.17% 6 32.50% 5 2.50% 3 0.83%
	IB	7 79.17% 6 19.17% 5 1.67%	7 75.00% 6 24.17% 5 0.83%	7 87.50% 6 10.00% 5 2.50%	7 74.17% 6 20.00% 5 4.17% 3 1.66%	7 72.50% 6 24.17% 5 1.67% 3 1.67%	7 77.85% 6 18.24% 5 3.91%	7 82.50% 6 15.83% 5 0.83% 3 0.83%
	Difference in means							
	Pearson Chi-square (p-value)	0.07[a]	0.06[a]	0.22	0.32	0.120	0.16	0.05 [b]
T3: Information presented three times	Local	7 59.66% 6 36.13% 5 4.20%	7 56.30% 6 41.18% 5 2.52%	7 66.39% 6 31.09% 5 2.52%	7 47.90% 6 45.38% 5 5.88% 3 0.84%	7 56.30% 6 41.18% 5 2.52%	7 53.27% 6 31.82% 5 10.51% 4 4.40%	7 58.82% 6 38.66% 5 2.52%
	IB	7 80.67% 6 15.13% 5 4.20%	7 80.67% 6 16.81% 5 1.68%	7 88.24% 6 7.56% 5 4.20%	7 66.39% 6 27.73% 5 5.04%	7 78.99% 6 15.97% 5 4.20%	7 78.83% 6 17.28% 5 3.89%	7 84.03% 6 11.76% 5 4.20%
	Difference in means							
	IB vs. Local	0.02[b]	0.07[a]	0.09[a]	0.23	0.01 [b]	0.11	0.09 [a]

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level

Source: Author's estimation.

2.3.3 Economic evaluation

Table 3.4 shows the mean WTP results for the two bean types. According to these results, the average WTP for the IB variety is marginally higher in all three treatments, although these differences between the WTP for the IB variety compared to the traditional variety are not statistically significant either across or within the three treatments. Therefore, consumers value both varieties equally, and the presence of information and the frequency in which it was received did not have a significant impact on consumers' WTP. Those results are in contrast to those obtained by Oparinde et al. (2016c) who found that information had a significantly positive effect on WTP premium and that providing the nutritional information (loss frame) three times versus once significantly increased consumer demand for the WIB variety.

Table 2.5 Mean WTP for bean varieties.

Variety	**Average WTP± S.D.(Quetzals)**
Iron biofortified variety ('super chiva')	
IB (T1)	4.83±0.71
IB (T2)	4.96±0.83
IB (T3)	4.89±0.76
Traditional variety ('parramos')	
Traditional (T1)	4.70±0.72
Traditional (T2)	4.67±0.74
Traditional (T3)	4.67±0.71
Within treatment comparison (% difference)	**Premium/Discount**
T1 (IB vs. Traditional)	2.76%
T2 (IB vs. Traditional)	6.20%
T3 (IB vs. Traditional)	4.71%
Across treatment comparison. WTP premium= IB-Traditional (% difference)	
T1 vs. T2	-2.62%
T1 vs. T3	-1.22%
T2 vs. T3	1.43%

Average market price: 5 Q./pound

Source: Author's estimation

2.3.4 Econometric analysis

Determinants of premium for the iron-enriched bean variety

To identify which econometric approach should be used, a Hausman test was run to accept or reject the null hypothesis that the preferred model had random effects or fixed effects. It tested whether the unique error (μ_i) was correlated with the regressor, and the null hypothesis showed they are not (Torres-Reyna, 2007). With a Prob>chi2 = 0.6990, random effects were used.

A Breusch-Pagan Lagrange multiplier test was also run to decide between random effects regression and a simple OLS regression. With a prob > chibar2 = 0.00, the null hypothesis that states that variances across entities are zero was rejected, then, random effects was appropriate in this case. An OLS model was also estimated to check the robustness of the results, but its results are not presented because the model was not significant.

The results of regression models estimating the effects of information and its repetition on participant premiums for the iron-enriched bean are presented in Table 3.5. Socioeconomic variables and cross terms are only included in cases where these variables are not strongly correlated, to avoid potential multicollinearity issues. Model 1 is the random effects, and models 2 and 3 are the right censored and interval censored ones. Robust standard errors are reported for all models. Coefficients are compared across models, and models are compared using R^2 as a measure of goodness-of-fit. For the right and interval-censored model, squared multiple correlations were computed (R^2 equivalent) between predicted and observed values of premium to compare this model with the random effects estimations. In all cases, partial models were estimated, the first one controlled for the treatment variables (Information and repetition); the second controlled for treatment and socioeconomic characteristics; the third one controlled for interaction variables and the fourth and last controlled for all variables (full-sample models), interactions included. Full-sample models performed better than the partial-sample models (higher R^2); thus, the latter were not reported. To compare between the full right and interval censored models, Akaike information criteria (AIC) are shown. Models with the lowest Akaike (AIC) gave better predictions.

Among the three sample models, the R^2 was not significant different, 0.14 in model 1 and 0.13 in models 2 and 3. Since the AIC for model 2 (right censored) was lower than for model 3 (interval censored), model 2 predicted better. Based on those results, we choose to focus our analysis and discussion on model 2, with some references to results in models 2 and 3 whose results are similar.

In model 2, information once and variety delivery order played an important role in WTP premium determination, showing that the role of information depended on the variety delivery order. When the IB variety and nutritional information were delivered on the first day, the WTP premium was 0.5 Q.; this premium was almost 80% higher than those receiving the IB variety on the first day but without any nutritional information. For those receiving the local variety and nutritional information on the first day, the WTP premium was 65% higher compared to those who received nutritional information and the IB variety on the first day. Those differences were large and significant at 1%. Those results show that the impact of information depends on the order of the variety delivery. It is possible that respondents associated the information they received with the variety that was delivered the same day, even if they had previously been informed about which variety was delivered on that day. Although the first difference in WTP premium (80%) was higher than the second one (65%) this implies that nutritional information had a positive and significant impact on WTP premium of 15% regardless of the delivery order. For educated respondents, with higher IRI, receiving the IB variety first and nutritional information once the WTP premium was 38% higher than those with similar characteristics but without information. These results are similar for models 1 and 3.

According to models 1 and 2, the WTP premium for men receiving nutritional information on three separate occasions was lower than for women. Those results can be explained in terms of differences in information processing between men and women. Putrevu et al. (2017) stated that women might benefit more from verbally descriptive messages and men would more from nonverbal reinforcement, e.g. pictures, music, etc. Women seems to have memory advantages for visual and verbal stimuli in advertisements compared to men who might require nonverbal reinforcement of the verbal product information (Edens and McCormick, 2001). According to Arganini et al. (2012) men usually show skepticism and resistance to nutritional messages especially in less educated and wealthier groups. A higher WTP premium was expected for wealthier men who received information reinforcement. For men with higher IRI and who received repeated nutritional information, the WTP premium was 72% lower than for women with similar characteristics. Similarly, the effect of nutritional information repetition was 18% higher for those with high IRI than for those with lower values in this index. This shows that information repetition was effective in this population but information delivered just once was not effective. When nutritional information was given once for those with high IRI, the WTP premium was lower. Those results indicate that respondents may not have understood the information, and information enforcement may have helped to iron out any misunderstandings. Respondents also tended to link the nutritional information they received with the bean variety they received on the same day although they were not told which variety they were actually receiving and they may have received a traditional variety which did not have any additional nutritional benefits. The low nutritional and socioeconomic status of most of the respondents might explain this behavior. In addition, the message was transmitted in Spanish (which they spoke) but Mam, not Spanish, is their native/mother tongue. Some misunderstanding could have been generated because of the choice of language used.

Older respondents and those with higher FFI had a lower WTP premium than those with opposite characteristics. Older respondents are usually less willing to try new things, especially those whose benefits are not visible immediately. And those with high FFI probably thought that they had a good diet and their nutritional requirements were completely filled. Those planting and consuming beans and with grain stored at home had a marginal higher but positive WTP premium than others. It may be related to their tradition of producing or consuming beans, which determine their diets and livelihoods.

Table 2.6 Determinants of WTP premium for the iron-enriched bean variety in Guatemala – Random effects model, right censored model and interval censored model

	Random effect model (1)	**Right censored model (Tobit) (2)**	**Interval censored model (3)**
Information once	0.36	0.94[c]	0.41[b]
	(0.29)	(0.57)	(0.17)
Information repetition	-1.17	-0.10	0.18
	(0.20)	(0.40)	(0.15)
Variety delivery order	-0.28 [b]	-0.49[b]	-0.43[b]
	(0.12)	(0.0.24)	(0.17)
Men x information once	0.07	0.02	0.43
	(0.27)	(0.55)	(0.30)
Men x Information repetition	0.38 [b]	0.80[c]	0.35
	(0.16)	(0.29)	(0.26)
IRI x information once	-0.26 [b]	-0.43[a]	-0.12
	(0.12)	(0.23)	(0.12)
IRI x Information repetition	0.13 [c]	0.18[b]	-0.11
	(0.04)	(0.09)	(0.09)
Education x information once	-0.04	-0.18[c]	-0.04
	(0.03)	(0.07)	(0.03)
Education x information repetition	0.05	0.08	-0.02
	(0.03)	(0.07)	(0.03)
Variety delivery order x information once	0.53 [b]	0.05[b]	0.62[b]
	(0.22)	(0.04)	(0.24)
Variety delivery order x information repetition	-0.00	-0.02	0.32
	(0.00)	(0.01)	(0.26)
Male	0.03	0.23	-0.27
	(0.16)	(0.31)	(0.19)
Age	-0.00	-0.02[c]	-0.01[b]
	(0.00)	(0.01)	(0.00)

Standard errors in parentheses

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level

Table 2.6 (*Cont*.) Determinants of WTP premium for the iron-enriched bean variety in Guatemala – Random effects model, right censored model and interval censored model

	Random effect model (1)	**Right censored model (Tobit) (2)**	**Interval censored model (3)**
Area planted with beans in 2013	0.00 [c]	0.00[c]	0.00
	(0.00)	(0.00)	(0.00)
Produce beans frequently	-0.07	-0.28	0.03
	(0.12)	(0.25)	(0.12)
Amount of beans stored at home	0.00	0.02[b]	0.00
	(0.00)	(0.01)	(0.00)
Purchase beans frequently	-0.02	0.05	-0.01
	(0.05)	(0.11)	(0.03)
Consume beans frequently	-0.00	0.00 [a]	0.04
	(0.03)	(0.07)	(0.02)
Poverty index	0.04	0.31	0.37[a]
	(0.11)	(0.22)	(0.21)
Food frequency index	-0.00[c]	-0.02 [c]	-0.00
	(0.00)	(0.01)	(0.00)
Monthly expenses	0.00	0.00	0.00
	(0.00)	(0.00)	(0.05)
Have met any people in the community	0.02	0.07	-0.21
	(0.05)	(0.10)	(0.15)
Have heard about iron in food	-0.22	-0.40	0.45
	(0.15)	(0.30)	(0.36)
_cons	0.39	1.66[b]	-0.05
	(0.34)	(0.70)	(0.04)
N	359	359	359
Likelihood-ratio test for heterocedasticity (Prob > chi2)	0.14	0.23	0.18
F statistic/Chi^2	0.00	0.00	0.00
Prob > F/Prob>Chi^2	89.52	106.07	30.53
R-squared	0.14	0.13	0.13
AIC		1,350	1,420

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level

Source: Author’s estimation

2.4 CONCLUSIONS AND DISCUSSION

The aim of this study was to investigate the consumer acceptance of an iron-enriched bean (IB) variety ('super-chiva') compared to a popular traditional local bean variety ('parramos') in northwest Guatemala.

We tested the impact of nutritional information of the IB variety, and the impact the frequency with which such information is provided on consumer acceptance. We have collected both sensory evaluation data using hedonic rating methods and economic evaluation data using a BDM auction mechanism. The data was collected using the HUT approach and a total of 360 households took part in this study. In each household, the principal respondent was the main decision-maker on bean consumption and purchase decisions. One-third of these households were asked to evaluate the two bean varieties without receiving any information on the nutritional benefits of the IB variety (control group – treatment 1), one-third received information through simulated radio messaging (treatment 2), and one-third received the information three times – once every day during the duration of the experiment (treatment 3).

Sensory evaluation data revealed significant differences for only some of the bean attributes investigated. Among those that did not receive information (Treatment 1 – control group), significant differences were found between the two varieties' cooking time and cooked bean thickness. In the information treatments (2 and 3) significant differences were found for raw bean color, raw bean size, bean taste and cooking time. In all cases, the IB variety was rated higher. The WTP values stemming from the BDM mechanism were however not statistically significant different for the two bean types, either across or within treatments, although average WTP values for the IB variety were higher in each treatment.

Based on these results, it is expected that consumers liked the IB variety as much as the traditional bean variety. Although respondents rated the IB variety higher in general, the sensory evaluation revealed a marginal (though not statistically significant) premium, and therefore, we cannot conclude that the IB variety is preferred over the local one in this context. Notwithstanding the insignificant differences, the possible respondent and household level variables that may affect the magnitude of the WTP premium were investigated using interval censored, right censored and random effects estimation methods. More than 15% of the bids for both iron-enriched and local varieties were censored at market price level for both varieties. As the respondents were given explanations about the implications of bidding a low or a high WTP, most of them bid the median (50 percentile) of the uniform distribution of potential market sale prices that they were competing against. This was done to reduce the risk of paying more than their real WTP, or losing out an opportunity to purchase a desired bean variety. The respondents with higher social interaction and higher education or income (welfare) made a uniform distribution of risks and probabilities. Further, an analysis using participation bids at the beginning of the experiments was done to validate if this method reduced the percentage of censored bids.

The results showed that nutritional information delivered once had a positive impact on WTP premium for the iron-enriched variety, but this are reforced when the IB variety and the information were given on the same day. The order in which the varieties were delivered had a significant effect on WTP premium as respondents tended to associate the variety they received with the message they heard on the same day. The order in which the variety was tested is likely to affect the WTP results. A randominization on the day in which respondents in this group would receive the nutritional information might help to overcome this issue. A reinforcement on which variety the are actually receiving each day might also help. Another important finding was that there was a lack of understanding from respondents who might have needed information reinforment, as it was evident that that nutritional information had a lower impact when it was given once to more educated or respondents with a higher retention index while the impact was higher with repetition in these groups. The language used in the message and the socioeconomic status of the respondents might be related to this behavior. Trying different alternatives to delivering the message (i.e. something more visual or as a video) and using the local language (Mam) should be tested in future research studies.

Information repetition mattered when men received it, especially men with high IRI. Men might require verbal reinforcement of the product information. According to Oparinde et al. (2016c), the frequency of providing the information matters if the information is of loss frame, suggesting the existence of loss aversion in participants' demand for the iron-enriched bean varieties. Possible information contamination or inadequate messaging may be potential causes. Further consumer acceptance studies in Guatemala should test the role that loss frame information might play and how its repetition could impact on WTP for the iron-enriched bean variety.

This study has shown that preference elicitation experiments´ context could also generate bias through the subject's submission of censored bids. Aspects such as social interaction, level of education, income and other welfare indicators could be related to the potential bias generated. Further research should be done to evaluate the potential role that the out-of-pocket payment may have on this bias.

These results were significant for future research on consumer acceptance of biofortified crops to avoid potential biases and to generate more accurate estimates for the WTP for the varieties evaluated. Results related to the role of nutritional information and its repetition should be taken into account for biofortified crops' dissemination strategy in order to potentiate their adoption in target populations and increase their impact in reducing micronutrient deficiencies mainly in rural populations. This also applies to population segmentation based on welfare or gender characteristics, as they should also be taken into consideration.

Ethical approval: "All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

Conflict of interest: The authors declare that they have no conflict of interest.

2.5 ACKNOWLEDGEMENTS

We would like to thank Prof. Jason Lusk for his valuables comments and suggestions during his review of the first draft of this paper. Thanks also to HarvestPlus for providing the funding and to the reviewers for their valuable contributions.

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3. IDENTIFYING SOCIOECONOMIC CHARACTERISTICS DEFINING CONSUMERS' ACCEPTANCE FOR MAIN ORGANOLEPTIC ATTRIBUTES OF AN IRON-BIOFORTIFIED BEAN VARIETY IN GUATEMALA

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The article in this chapter is published on *International Journal on Food System Dynamics*, Volume 8, Issue 3. It was originally submitted on October 6th, 2016, re-submitted for review on May 3rd, 2017, and accepted on June 12th, 2017 for publication.

ABSTRACT

The success of biofortification, the process of generating new staple crops varieties with higher micronutrient content, depends on whether those biofortified cultivars are accepted by target populations. Consumer behavior economics argues that socioeconomic, cultural and biological characteristics define consumer preferences for specific product attribute. This study aims to establish which socio-demographic characteristics predict respondents' preferences for the main sensory attributes of an iron bean variety. A home use testing approach and sensory evaluation was applied to 360 families in northwest Guatemala. We found that revealed preferences are mostly culturally formed and market related, more than influenced by socio-demographic characteristics.

3.1 INTRODUCTION

At the global level more than 30 percent of the population, i.e. 2 billion people are anemic mainly due to iron deficiency. This is the most common and widespread nutritional disorder in the world constituting a public health condition of epidemic proportions (WHO, 2014). Although many strategies including food fortification, dietary diversification, and supplementation have been developed to address this disorder as well as other micronutrient deficiencies of importance, biofortification has emerged as the most promising complementary strategy that attempts to overcome mostly micronutrient deficiencies without changing dietary habits (Banerji et al., 2013).

Biofortification is the process of breeding and delivering staple food crops with higher micronutrient content (Saltzman et al., 2013). It is an important cost-effective strategy used mostly for rural areas in developing countries where high levels of micronutrient deficiencies coexists with high production and consumption of staple crops such as beans, rice, maize, and cassava (Meenakshi et al., 2010; Asare-Marfo et al., 2013; Saltzman at al., 2013).

Guatemala has one of the highest prevalence of iron deficiency in Latin America, i.e. in rural areas 24 percent of the children and 20.1 percent of the women are affected (MSPS, 2012). This country also has one of the highest rates of bean consumption per capita in the world, i.e. 12.4 kilograms/person/year (FAOSTAT, 2011). Therefore, iron-biofortified bean cultivars appear to be an alternative to tackle this nutritional disorder in this country.

The success of biofortification depends on whether the biofortified cultivars are accepted and consumed by target populations (Meenakshi et al., 2010). Acceptance and consumption is mainly based on consumer preferences which depend among others on various organoleptic or sensory characteristics such as taste, color, and texture, among others (Costell et al., 2010). Previously, as part of this study a market survey was carried out in Guatemala City and in the west region asking bean consumers and retailers about their preferences when purchasing, cooking and eating beans. Characteristics as color, cooking time, flavor and cooked bean thickness were stated as the most important characteristics for a bean variety to be accepted and consumed at home. Regarding bean color, darker and brighter colored grains are preferred. These two attributes are pointed out as synonymous of freshness. Less cooking time means that the grains are fresher, and consequently less wood for cooking is required; thus, their higher acceptance and consumption. Flavor and cooked bean thickness are important especially for children´s acceptability. Mainly in rural

Guatemala children are fed with bean broth and children's acceptance plays a relevant role in the society´s nutritional status.

Although some studies have analyzed consumer acceptance of biofortified crops in Africa using sensory evaluations (Stevens at al., 2008; Meenakshi et al., 2010; Pillay at al., 2011; Talsma at al., 2013; Oparinde et al., 2014; Oparinde et al., 2015), such a study has not yet been carried out in Latin America where the commercial use of biofortified crops is in an early stage. On the other hand, no study evaluating consumer acceptance of biofortified crops has established socioeconomic and demographic characteristics predicting each respondent's acceptance, i.e. hedonic score for each of the iron bean variety´s attributes evaluated. According to consumer behavior economics, consumer's preferences for specific product characteristics are determined by socioeconomic, cultural and biological aspects as gender, level of education, wealth, knowledge, and even neurons (Triplett, 1995; Troemel et al., 1997; Moerbeek & Casimir, 2005). These factors are identified in consumer decision models as external variables influencing consumers' decision process (Bray, 2008). Identifying these factors will help to understand much better consumers' preferences and behavior through the identification of an accepter profile according to each organoleptic attribute evaluated. This information will be useful for breeders and other specialist related with crop biofortification development and dissemination to present new and improved crops to consumers with higher acceptance potential.

Through the exploration and use of a database designed and built to analyze the consumer acceptance towards an iron bean variety, this study attempts to fill the literature gaps on consumer acceptance of biofortified crops by evaluating the main factors defining consumer acceptance for main organoleptic characteristic of an iron-fortified bean variety named *Super Chiva* (74 ppm of iron) over a traditional one named *Parramos* (50 ppm of iron) in rural west Guatemala.

The main objectives of this paper are to (1) make a novelty use of a consumer acceptance study database to try to extract new information never analyzed before; (2) assess consumer preferences regarding the main organoleptic characteristics of an iron-fortified bean cultivar compared to those of a traditional one; (3) establish the main socioeconomic and demographic characteristics predicting these preferences; and (4) segment consumers into groups based on their characteristics, preferences, and attitudes toward iron-fortified beans.

This paper is organized as follows: Section 2 gives further details on the study design, methodology used for data collection and analysis, section 3 discusses the results obtained, and section 4 provides main conclusions and discussion.

3.2 METHODOLOGY

This study was conducted under the ethical approval provided by the Ministry of Health and Education of Guatemala.

3.2.1 Study Sites and Sampling Design

The sensory evaluation experiment along with the socioeconomic survey was carried out in August 2013 in 12 communities of the San Sebastian Huehuetenango municipality northwest Guatemala. This study was part of a broader study carried out by the HarvestPlus project which attempts to elicit the willingness to pay (WTP) for each variety included in this study, and these results will be analyzed in another paper. This municipality was chosen due to its high chronic malnutrition prevalence (72.2 percent) (Gobierno de Guatemala, 2012), and finding high levels of iron deficiency affecting more than 30 percent of the children and pregnant women (MSPS, 2012). Moreover, people in the region have high levels of bean consumption and production along with suitable agroecological conditions for the production of an iron-fortified bean variety according to validation tests carried out by the Science and Institute of Agricultural Science and Technology (ICTA)[3] of Guatemala.

As the main goal of the experiment was to elicit the WTP for these varieties power calculations were conducted to determine the optimal respondent number to be surveyed. Bean price in northwest Guatemala varies by color. Red and white varieties are the most expensive ones and are cooked on special occasions, whereas black varieties are the cheapest and are consumed daily. In July 2013 the average market price for these bean varieties was 5 quetzals[4] per pound. Based on the average market price a treatment effect of 10 percent (0.5 quetzals) and a standard deviation in

[3] Personal communication with ICTA's bean breeder team.
[4] US$1 = 7.67 quetzals in July 2013 (http://www.oanda.com/currency/historical-rates/)

the market price per pound of 2.5 quetzals were anticipated. Using a 5 percent significance level and a power of 0.8 a sample size of 120 households for each treatment was established.

In total, 360 respondents or rural bean consumers were surveyed. The treatments were randomly assigned to all participants and each received a 1 pound sample of the iron-fortified bean variety and one of a local variety to cook, eat and evaluate at home according to their appointed treatment.

The bean varieties used in this study were both black varieties. One is a high iron-fortified bean (HIB) variety (*super chiva*) with 75 parts per million (ppm) of iron, and the other is the local variety (*parramos*) with 50 ppm of iron. The iron-fortified variety used in this study was provided by ICTA and had been cultivated in the first season of 2013, and the traditional variety was obtained from a local farmer who cultivated it in the same season under similar conditions.

The objective of our sampling strategy was to draw a sample of 360 households from different communities of the San Sebastián Huehuetenango municipality. Unfortunately there were no reliable secondary data from recent censuses to determine the total number of people or households in the municipality. Likewise, no official data that could reliably give an estimate of the current population in each community existed. Therefore, local experts and community leaders in San Sebastián Huehuetenango were asked to estimate approximately the current population size in the municipality and in each of the communities mentioned.

Data collection took place during the rainy season which made transportation of the enumerator teams to some communities very difficult, if not impossible. Moreover, remote communities had higher security risks and locals were somewhat reluctant to participate in any kind of study. As a result, a list of 20 accessible and less remote communities was drawn from which 12 were randomly chosen. Within these communities enumerators randomly selected the households to participate in the study, selecting every fifth or seventh household they found in the road depending on the size of the community. To prevent contamination or leakage of the nutritional information through social networks the control treatment, i.e. without information was established during the first week, and the other two treatments were established in the following two weeks.

3.2.2 Sensory Evaluation and Survey Procedure

In this study we used the HUT method in which selected households received 1-pound of grain of both bean varieties (one variety each day in a random order) to cook and eat at home. Based on an average household size, demographics and information on quantity of beans consumed per person in the region, 1-pound was calculated to be sufficient for an average breakfast and lunch consumption per household. Each sample was packed in transparent plastic bags looking similar externally. However, these were differentiated using geometrical shapes on the plastic bags: a triangle for the iron-biofortified variety and a square for the local variety. Only those in treatments 2 and 3 were informed about how to distinguish between the iron-fortified and the traditional varieties. Each consumer had a chance to experience and to evaluate the following sensory and cooking attributes: raw bean color, raw bean size, bean taste, cooking time and cooked bean thickness. They were also given the opportunity to review the overall evaluation. Each of these attributes was evaluated on a 7-point Likert scale ranging from 1 (dislike very much) to 7 (like very much), with other levels being 2 (dislike), 3 (dislike a little), 4 (neither like nor dislike), 5 (like a little), and 6 (like).

The evaluation lasted three days and was carried out as follows:

Day 1: Before describing the study and asking their consent to participate the subjects were asked about their knowledge regarding iron-fortified bean varieties. Those who revealed any knowledge were not included to avoid bias in their answers based on their previous experience or information. Following this, they were asked about their knowledge on food purchasing and cooking at home, and only those with knowledge of any of these aspects were surveyed. After signing a consent form they were randomly assigned to one of the treatments and received 1-pound of the bean sample they had been appointed to receive. They were then requested to cook the sample following their usual cooking practices[5] and without mixing it with any other bean varieties they may already have at home. The households were visited early in the afternoon as households usually cook their beans in the evening to consume at breakfast and lunch the following day. Each household was given one day to cook and consume the variety as one day was thought to be sufficient time to generate an opinion about the variety, while reducing the risk of information contamination through social networks.

[5] Most of the families boil the beans without any other ingredient. However, when available some traditional culinary weeds are used.

Day 2 (after lunch): The enumerator visited the same household again to conduct the sensory evaluation of the delivered variety on day 1 and to provide a sample of the other variety according to the treatment they were appointed to.

Day 3 (after lunch): The sensory evaluation for the second sample was carried out on the third day.

3.2.3 Survey and other Tools used

A survey tool was designed in collaboration with local experts and was pretested prior to data collection. Because of its length the survey was divided into three parts and each part was completed per day. In treatment arms the information about nutrition and other characteristics of the iron-fortified bean variety was given through a recorded (simulated) radio message that the respondents listened to on individual MP3 devices. Qualitative background studies and the literature review carried out prior revealed that simulated radio messaging was the most effective mean to transmit information in rural Guatemala, where illiteracy is traditionally high especially in indigenous communities, and where radio ownership and use is high, i.e. close to 90 percent (Avila Pinto, 2010). This nutrition message was recorded in Spanish using local vocabulary and phrases. The content of the message was developed and validated by nutritionists as well as by local leaders. This message includes topics related to agronomic and nutritional characteristics of the HIB variety and its potential benefits for children and women's health. This message was mainly heard by participants to avoid information leakage or contamination.

3.2.4 Data Analysis

Ordinal Probit Regression

Unlike previous studies that evaluated hedonic attributes (Meenakshi et al., 2010), in this study scores for the main organoleptic characteristics were not highly correlated (see Table 3.1). This allowed the use of an ordinal probabilistic regression to analyze the socioeconomic and demographic factors determining the premium/discount acceptability hedonic scores for all the attributes evaluated. As a discrete ordinal scale was used to measure consumer liking, the data was of an ordinal nature as their order is meaningful and therefore an ordinal probabilistic regression must be used (Meullenet at al., 2007). In a probabilistic regression model for an ordinal categorical response the response variable (Y) can be represented as a latent, continuous, and unobservable variable (Z). We cannot observe Z but we can observe the difference in "Y" between the scores consumers give to the same attribute for the iron-fortified and traditional bean varieties. The relationship between Y and Z can be described as follows:

$Y = 1$ = dislike very much if $-\infty < Z \leq \alpha_1$

$Y = 2$ = dislike if $\alpha_1 < Z \leq \alpha_2$

$Y = 3$ = dislike a little if $\alpha_2 < Z \leq \alpha_3$

$Y = 4$ = neither like nor dislike if $\alpha_3 < Z \leq \alpha_4$

$Y = 5$ = like a little if $\alpha_4 < Z \leq \alpha_5$

$Y = 6$ = like if $\alpha_5 < Z \leq \alpha_6$

$Y = 7$ = like very much if $\alpha_6 < Z < \infty$

Where α_is are the acceptability thresholds that cannot be observed but can be estimated.

Table 3.1 Correlation matrix among beans attributes

Attribute	**Color**	**Size**	**Flavor**	**Cooking Time**	**General**
Color	1				
Size	0.6123	1			
Flavor	0.4752	0.2977	1		
Cooking Time	0.2817	0.2865	0.0851	1	
General	0.5082	0.3588	0.4696	0.0488	1

Source: Author's estimations

The model can be specified as:

$Z_i = X'_i\beta + \mu_i$ (1)

$Y_i = j$ if $\alpha_{j-1} < Z_i < \alpha_j$ (2)

Where Z is a continuous latent variable for consumer i varying from $-\infty$ to ∞ corresponding to the observed response Y_i^*, and X'_I is a vector of covariates for consumer I; β is a vector of regression coefficients; and μ_i is the i^{th} random error. Y_i is the observed difference between the hedonic score for the iron-fortified variety and the traditional one.
The probability that the response of the i^{th} consumer will fall in the j^{th} category or below (denoted by p_{ij}), given X_i, is given by:

$$p_{ij} = p\,(y_i = j) = p\,(\alpha_{j-1} < y_i^* \leq \alpha_j) = F\,(\alpha_j - X'_i\beta) - F\,(\alpha_{j-1} - X'_i\beta) \quad (3)$$

Where F is the cumulative distribution of ε: $F\,(\varepsilon) = \frac{e^{\varepsilon}}{1+e^{\varepsilon}}$ (4)

The marginal effects can be computed as follows:

$$\partial\, p_{ij} / \partial\, x_{rj} = \{\, F'(\alpha_{j-1} - X'_i\beta) - F'(\alpha_j - X'_i\beta)\}\; \beta_r \quad (5)$$

Cluster Analysis

Cluster analysis is a technique that allows the segmentation of observations by how well they align with a chosen set of explanatory variables (Hair et al., 1998). Groups of related variables can be formed as in a factor analysis. In a cluster analysis assumptions about the underlying distribution of data are not required as they are used for factor analyses and regressions. A common criticism of the cluster analysis is that it is not a robust statistical method and is highly dependent on the choice of the explanatory variables and the clustering method. It is also more difficult to extend the results of a cluster analysis to a larger population than it is for other statistical techniques such as a regression analysis. However, a cluster analysis is appealing because it allows the sorting of observations into distinct groups (Gifford and Bernard, 2008).
Hierarchical clustering procedures must be used when there is a small data set and you want to easily examine solutions with increasing numbers of clusters. For hierarchical clustering a statistical method that quantifies similarities or dissimilarities between two cases must be chosen before forming groups, and finally the number of clusters required for the representation of the data must be determined (Norusis, 2011). As we have a mixture of categorical and continuous variables a similar method is used as a criterion to form similar groups. None of the distance

measures in hierarchical clustering is suitable for use with both types of variables (Norusis, 2011). Therefore, a factor analysis of mixed data (FAMD) is used to group all in a sole index. Then a hierarchical clustering on principal components is used. This makes an agglomerative hierarchical grouping using results from a factorial analysis.

The independent variables included in the models are shown in Table 3.2. Those variables were selected based on previous literature review about the factors defining consumer preferences towards organoleptic characteristics for different types of products.

Table 3.2 Independent variables included in different models

Variables	**Description**
HHmembers	Continuous variable indicating the number of persons living in the respondent's household
Children	Households with children or babies less than 4 years old
Women	Households with pregnant women or breastfeeding women
Beancons	Continuous variable indicating the weekly amount of beans consumed by the household
Nopurchase	= 1 if the household does not purchase beans; 0 otherwise
Agriculture	= 1 if agriculture is the main household income
Progress out of Poverty Index (PPI)	Grameen Foundation's PPI accounts for head of household's education, assets and income (calculated by the authors from survey data; explained below)
Age	Continuous variable indicating the respondent´s age
Gender	= 1 if the respondent is male; 0 otherwise
Quiencompra3	= 1 if a man is the person who purchases beans in the household
Education	= 1 if the education level is higher than the medium level
Household planting	= 1 if the household plant´s beans every year
Varorder	= 1 if the iron-fortified variety was received first; 0 otherwise
Talk4	= 1 if the respondent talked with somebody else about this study in the last 4 days; 0 otherwise
Treatment 2	= 1 if the respondent was in treatment 2; 0 otherwise
Treatment 3	= 1 if the respondent was in treatment 3; 0 otherwise
Genderxtreat2	Interaction between gender and treatment 2
Genderxtreat3	Interaction between gender and treatment 3

Source: Author's estimation

The Progress out of Poverty Index® (PPI)

The PPI is a poverty measurement tool developed by Grameen Foundation (Grameen Foundation, 2015). The index is computed using the answers to 10 questions on household characteristics and asset ownership to determine the likelihood that the household is living below the poverty line (US$1.25/day 2005 purchasing power parity). The country-specific PPI consists of a set of 10 specific questions for 45 countries. In this study country-specific questions for Guatemala were asked. When the PPI was higher the likelihood of a household to be below the poverty line was lower.

Interaction Variables

Interactions between treatment variables and gender and education were also included. Interaction with gender (genderxtreat2 and genderxtreat3) looks for any gender implication in a possible information and repetition on consumer acceptance effect of the iron-fortified varieties. For example, women are perhaps more susceptible to attend to nutritional information than men. In the same direction the interaction of these treatment variables with education was included (edutreat2 and edutreat3). Thus, a higher information effect on participants with higher education was expected. Moreover, interactions with receiving the iron-fortified variety (varorder variable) were also included, expecting that those receiving information and the iron-fortified variety the second day were willing to pay a higher price for this one.

3.3. RESULTS

3.3.1. Participant and Household Characteristics

Table 3.3 presents key socioeconomic characteristics of respondents and their households by treatment arm, and reports further the results of the ANOVA analysis for median homogeneity across the three groups. The characteristics listed are those hypothesized to affect respondent WTP.

Table 3.3 Socioeconomic characteristics by treatment group (ANOVA test)

Variable	**Mean (S.D.)**			
	Treatment 1 N=120	Treatment 2 N=120	Treatment 3 N=119	Prob. > F
HH membersb	6.32	6.06	5.46	0.02
	(2.53)	(2.67)	(2.10)	
Children	0.90	0.75	0.73	0.32
Women	0.28	0.26	0.16	0.16
Beancons	3.46	2.97	2.77	0.13
	(2.02)	(1.63)	(1.22)	
Nopurchase	0.025	0.033	0.033	0.90
	(0.50)	(0.60)	(0.42)	
Agriculture	0.66	0.59	0.58	0.98
Poverty Index	60.93%	66.47%	65.45%	0.31
	(0.32)	(0.28)	(0.28)	
Age	36.24	35.82	34.96	0.73
	(11.40)	(11.41)	(34.96)	
Genderc	0.45	0.23	0.37	0.00
Quiencompra3	0.25	0.17	0.11	0.13
Education	0.01	0.03	0.04	0.51
beanproducer	0.63	0.56	0.54	0.36
varorder	0.49	0.66	0.31	0.15
Talk4	0.28	0.39	0.35	0.20

c = statistically different at 1% significance level; b = statistically different at 5% significance level; * = statistically different at 10% significance level.

Source: Author's estimation

Most of the key participant's social and economic household level characteristics are similar across treatments revealing that randomization in treatments worked well. Statistical differences are observed for gender between treatment 3 and other groups, for the number of members per household between treatments 2 and 3, and for the percentage of households with small children between treatment 3 and the other two. Variables such as initial knowledge regarding iron deficiency and anemia and the quantity of beans they had at home were not significantly different across treatments. This showed similar iron deficiency and anemia awareness endowment and levels of product ownership among groups.

3.3.2 Consumer Acceptance for the Main Organoleptic Characteristics

Table 3.4 shows mean hedonic ratings for the two bean varieties. According to these results more than 80 percent of the participants scored both varieties above 6, i.e. between like and like very much. Those results are similar for both varieties in the three treatments being marginally higher for the HIB variety for all the characteristics evaluated, except for cooked bean toughness in treatments 2 and 3. Those mean scores are statistically different for cooking time, cooked bean thickness, and the overall evaluation in treatment 1, as well as for raw bean color, raw bean size, bean taste, and cooking time in treatments 2 and 3. In the overall evaluation the HIB variety scored higher but this difference is only statistically different in treatment 1. Color, flavor, size, and cooking time are included in the analysis because of their significant differences in most of the cases in at least two of the three treatments. The overall evaluation is included because of its relevance in the analysis.

Table 3.4 Home testing mean hedonic rating of bean varieties from northwest Guatemala

	Bean variety	Raw bean color	Raw bean size	Bean taste	Cooking time	Cooked bean thickness	Cooked bean toughness	Overall rating
Control (T1): No Information	Local (*Parramos*)	6.55±0.59	6.57±0.72	6.59±0.75	6.10±1.35	6.17±1.29	1.85±2.95	6.47±1.00
	HIB (*Super chiva*)	6.63±0.72	6.61±0.67	6.75±0.74	6.58±0.74	6.66±0.66	1.95±3.07	6.66±0.66
				Difference in means				
	HIB vs. local	0.75	0.042	0.16	0.47[c]	0.49[c]	0.11	0.19[a]
T2: Information presented once	Local (*Parramos*)	6.53±0.46	6.50 ±0.56	6.63±0.52	6.37±1.09	6.40±0.93	1.42±2.73	6.59±0.63
	HIB (*Super chiva*)	6.77±0.65	6.74±0.46	6.85±0.42	6.64±0.76	6.60 ±0.91	1.21±2.63	6.60±0.91
				Difference in means				
	HIB vs. local	0.24[c]	0.24[c]	0.21[c]	0.26[b]	0.19	-0.21	0.01
T3: Information presented three times	Local (*Parramos*)	6.55±0.57	6.54±0.55	6.63±0.53	6.39±0.67	6.53±0.54	1.34±2.63	6.59±0.59
	HIB (*Super chiva*)	6.76±0.51	6.77±0.51	6.84±0.46	6.57±0.77	6.64±0.96	1.15±2.51	6.64±0.96
				Difference in means				
	HIB vs. local	0.21[c]	0.23[c]	0.20[c]	0.17[a]	0.11	-0.19	0.06

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level

Source: Author’s estimation

Table 3.5 presents comparisons of hedonic ratings across treatments. For the local variety statistically significant differences were found for cooking time between treatment 1 and treatments 2 and 3, and for cooked bean thickness between treatments 1 and 3. When estimating consumers’ preferences for the HIB variety across the different scenarios, significant differences were found for raw size and cooked bean toughness between treatment 1 and the other treatments. This shows that consumers preferred those attributes when information is provided. When evaluating the impact of the information frequency comparing treatments 2 and 3 no significant differences were found.

Table 3.5 Mean hedonic rating of bean varieties across treatments (difference in means)

Treatment group	**Raw bean color**	**Raw bean size**	**Bean taste**	**Cooking time**	**Cooked bean thickness**	**Cooked bean toughness**	**Overall rating**
Local: T1 vs. T2	0.025	0.075	-0.041	-0.266[a]	-0.233	0.425	-0.116
Local: T1 vs. T3	0.003	0.037	-0.046	-0.286[b]	-0.362[c]	0.505	-0.113
Local: T2 vs. T3	-0.021	-0.037	-0.005	-0.019	-0.129	0.080	0.003
HIB: T1 vs. T2	-0.14[a]	-0.125[a]	-0.091	-0.058	0.066	0.75[b]	0.066
HIB: T1 vs. T3	-0.13	-0.156[b]	-0.082	0.011	0.019	0.80[b]	0.019
HIB: T2 vs. T3	0.010	-0.031	0.009	0.070	-0.047	0.057	-0.047

a = statistically different at 1% significance level; b = statistically different at 5% significance level; c = statistically different at 10% significance level.

Source: Author’s estimation

3.3.3 Socioeconomic and Demographic Characteristics Determining Consumers' Preferences

The results from the ordinal probit regression for each of the attributes included in the analysis appear in Table 3.6. According to those results color of the iron-fortified bean variety is more likely to be accepted by those consumers in households in which agriculture is the main source of income with high bean consumption per week. On the other hand, the likelihood of being accepted will decrease in male consumers or in households with children less than 3 to 5 years of age, in traditional bean producer households or in those in which bean purchase is a male duty. Based on that, color of the iron biofortified variety is less likely accepted by those consumers with market orientation since men in rural communities are in charge of bean marketing and traditional bean producers tends to be market orientated and most of them in fact sell some of their surplus in markets. In the other side of the spectrum, color is more likely accepted by less wealthier consumers since a high proportion of their income comes from agriculture and have higher bean consumption or have less diversified diets. The fact that households with children under 3 years of age are less likely to accept color is because wealthier families do not use to feed their young children with beans, therefore the nutritional fact is not relevant. According to the variable gendertreat3, receiving the information trice increases the likelihood of acceptance by men showing some information effect.

Table 3.6 Coefficients of the ordinal probabilistic regression[6]

Variables	**Color**	**Size**	**Flavor**	**Cooking time**	**Cooked bean Thickness**	**General**
HHMembers	-0.02	-0.06b	-0.02	0.01	-0.02	-0.01
Children (0 to 3 years old))	-0.15a	0.07	0.07	-0.01	-0.06	-0.02
Women (Pregnant or breastfeeding women)	0.19	0.26a	0.27a	0.17	0.02	0.29a
Bean consumption at home	0.07a	0.05	0.06	0.06	0.04	0.05
Nopurchase	-0.39	-0.40	-0.88b	-0.40	0.01	-1.08c
Agriculture main income	0.32b	0.08	-0.15	0.16	-0.06	0.24a
Progress out of Poverty index (PPI)	0.26	0.10	0.06	0.14	-0.09	0.14
Age (Respondent's age in years)	-0.01	0	0.00	0.00	-0.01	0.00
Gender (=1 if respondent is male)	-0.49b	-0.04	-0.12	-0.46b	-0.05	-0.56c
Quiencompra3	-0.29a	-0.25	-0.23	-0.25a	0.15	-0.45c
Genderxtreat2	0.41	0.11	0.10	0.14	0.11	0.33
Genderxtreat3	0.71b	0.29	0.74b	0.53a	0.06	0.83c
Education (=1 if higher than medium level)	0.57	-0.16	0.34	0.42	-0.39	0.65a
HH planting beans every year	-0.24a	-0.09	-0.06	-0.03	-0.06	0.01
Treatment2	-0.03	0.28	0.11	-0.27	0.17	-0.18
Treatment3	-0.17	0.17	-0.18	-0.33a	0.01	-0.27
Varorder	-0.06	-0.04	-0.05	0.09	-0.65c	-0.03
Talk4	-0.12	-0.06	-0.35c	-0.05	0.06	-0.20
N.	359	359	359	359	359	359
Pseudo R-squared	0.04	0.03	0.04	0.02	0.04	0.05

c=statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level

Source: Author’s estimation

Regarding size, when the number of household members is higher the probability of acceptance is lower. This result reflects some bean producer opinions mentioning that *Super Chiva*´s grain is a bit smaller than the traditional variety´s grain, and in the region it is traditionally believed that bigger grains generate more hunger reduction. In other words, one pound of big grained beans is preferred over one pound with smaller grains. This fact increases the likelihood of acceptance among pregnant and lactating women since bigger grains sometimes are related with more stomach gases during pregnancy.

The iron-biofortified bean variety´s flavor is less likely accepted by self-sufficient households and those in which the respondent had talked about this study with somebody else in the last four days

[6] All variables were described on table 3.2.

before the sensory evaluation, reflecting some bias due to information contamination. The likelihood of acceptance increases in men receiving information trice and in households with pregnant or lactating women, reflecting some potential information effect.

Cooking time is less likely accepted by men mostly as male respondents in households are in charge of bean purchasing. However, in the case of information it seems there is an information effect since men receiving information trice increase their acceptance for this attribute.

In the case of cooked bean thickness there are no socio-demographic characteristics defining preferences for this attribute. But this is the only attribute in which the variety´s sample order distribution has an effect. In this case receiving the iron-fortified variety first decreased the acceptance likelihood of the cooked bean thickness attribute for this variety.

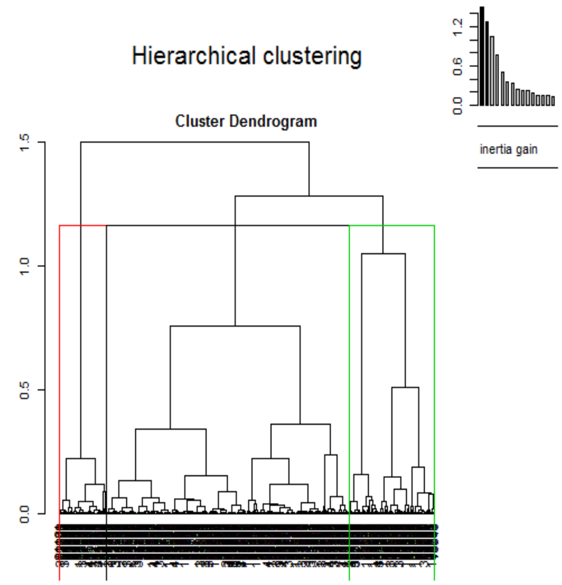
Men and households not purchasing beans are less likely to accept the iron-fortified variety for its organoleptic characteristics, and bean producers' households and those with higher education tend to accept the iron-fortified variety.

3.3.4 Cluster Analysis

As we are working based on a factorial analysis, the traditional test using in cluster methodologies is not possible because these are based only in qualitative variables. In this case, in order to have an optimal number of clusters the inertia sum inside each cluster was estimated. This inertia depends on the ratio in-between the groups and the total variance of the dispersion analysis (See appendix I). Based on that, three different clusters were defined using the agglomerative hierarchical cluster analysis (Figure 3.1).

Although most of the respondents showed a slightly higher preference for most of the iron biofortified variety´s organoleptic attributes, three clusters can be identified: "fully accepters", "slightly accepters" and "indifferent". Cluster number 3, i.e. the "fully accepters" are those preferring most of the organoleptic attributes of the iron-biofortified variety; cluster 2 presents a lower level of preference and cluster 1 gathered those indifferent among the attributes of both varieties. According to this cluster more than 50 percent of the respondents accept the traditional variety or are indifferent to any, and more than 35 percent accept the iron-fortified variety.

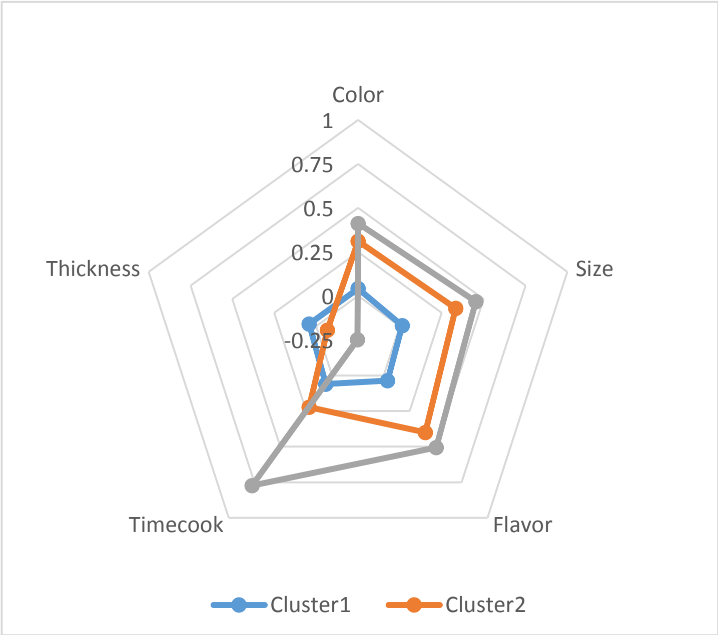
Figure 3.1: Results from the agglomerative hierarchical cluster analysis



Source; Author's creation

Figure 3.2 shows the main cluster characteristics based on participants' acceptance of the most important organoleptic characteristics evaluated. According to this figure cluster 3 "fully accepters" includes respondents with a higher acceptance for the color, size, cooking time and flavor of the iron-fortified variety than in the other clusters. Cluster 1 shows slight preference for all the attributes and cluster 2 is similar to cluster 3 in their preferences but shows a higher acceptance for the cooked bean thickness of the iron-fortified variety but a much smaller with cooking time.

Figure 3.2: Sensory evaluation of the iron-fortified bean variety by cluster



Source: Author's creation

Table 3.7 shows the main socio-demographic characteristics defining each cluster. Cluster 3 "fully accepters" is characterized by women with an average age of 35 years with lower bean consumption, bean purchase in market, lower probability of being under the poverty line and lower proportion of bean producers. Cluster 3 "slightly acceptance" is characterized by men with an average age of 39 years, no purchase of beans in market and higher education compared with the other clusters. Cluster 3 "indifferent" is characterized by bigger households with higher bean consumption, higher income from agricultural activities and being a bean producer.

Table 3.7 Main socio-demographic characteristics defining acceptance clusters (Media)

Variable	Fully acceptance	slightly acceptance	Indifferent
HH members	5.00	6.00	8.00
Children	0.60	0.70	1.20
Women	0.10	0.20	0.60
Beanconsume	2.60	2.73	4.29
Nopurchase (%)	1.40	6.70	5.20
Agriculture	46.10	71.10	83.50
Poverty Index	0.58	0.67	0.78
Age	35	39	39
Gender	16.60	100	48.50
Quiencompra3	19.40	11.10	19.60
Education	3.20	4.40	2.10
Bean producer	50.70	64.40	72.20
Varorder	48.40	31.10	58.80
Talk4	32.30	37.80	37.10
Genderatreat2	2.80	0	22.70
Genderatreat3	0	100	0

Source: Author's estimation

3.4. DISCUSSION AND CONCLUSIONS

This paper tries to use a consumer acceptance database to explore novelty alternatives to examine unanalyzed topics especially in the literature concerning the study towards the acceptance of biofortified crops varieties. This paper investigates the main socioeconomic characteristics defining consumers' preferences for the main organoleptic attributes of a bean variety with higher iron content compared with a traditional variety. The role of nutritional information and its repetition was also analyzed. The organoleptic attributes evaluated were color, size, flavor, cooking time and cooked bean thickness. Respondents were also given the opportunity to review the general evaluation.

As a result, a slightly higher but not statistically significant preference for the iron-fortified variety was estimated especially for attributes as color, size, flavor, and cooking time, depending on nutritional information and how frequently it is received. Preferences for these attributes are defined in most of the cases by socioeconomic characteristics related with bean production status and market orientation of the respondents or households. In this direction, aspects as no purchase of beans in the market, to be a bean producer or a bean consumer determines some of the preferences for these attributes.

Most of the socioeconomic characteristics explaining respondents preferences for most of these organoleptic attributes are related with the preferences stated by bean consumers during a marked survey carried out prior to this study, showing that there is a high relation between the revealed and the stated preferences. Characteristics as age, education level, and poverty level do not influence those preferences, indicating that the beliefs and revealed preferences are mostly culturally formed and market related more than influenced by socio-demographic characteristics.

Cluster analysis shows three clusters, i.e. fully accepters, slightly accepters and indifferent. Fully accepters are mainly wealthier women less related with bean activities as consumption, purchase and production. Slightly accepters are mainly men with higher education and traditionally not purchasing beans in the market. The indifferent are bean consumers and producers with less education and a higher probability of being under the poverty line.

Nutritional information does not seem to play an important role in consumer preference formation in contrast to what other studies had found. Repetition could however improve their acceptance of some of the iron-fortified variety attributes, especially when information is delivered trice to men.

For further analysis, less accessible communities should be included. Although traditionally people leaving on these communities don't have any access to markets, their specific socioeconomic characteristics might have some relevance on consumers' preferences.

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4. The impact of nutrition information on consumer acceptance of nutritious foods: A gendered analysis of iron-Enriched foods in India, Guatemala, and Rwanda

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The article in this chapter is under review by the Journal *of Food, Nutrition and Agriculture*. It was submitted on September 26th, 2018.

Abstract:

In this paper we present a gendered analysis of the consumer acceptance of iron biofortified beans in Guatemala and Rwanda and iron biofortified pearl millet in India. Each data set collected data on the consumer evaluation of the main attributes of iron biofortified crop varieties using a hedonic rating method (sensory evaluation) and consumer valuation (willingness to pay [WTP]) using the Becker-DeGroot Marschak mechanism. In each study, a popular local variety was used as a control. A home use testing (HUT) approach was used in Guatemala and Rwanda and a central location testing (CLT) approach was used in India. The differences in how men and women valued each variety and the impact that nutritional information and its repetition might have on the acceptance of iron biofortified variety was tested. Our results showed that women evaluated iron biofortified varieties differently to men. Our results also showed that the impact of nutritional information differed between men and women and had a more positive impact on men's WTP for iron biofortified varieties, mainly for more educated men. A complemented strategy to promote biofortified crops must be focused mainly but not only in the poorest, men and women, who usually are the least educated. To use pictures, videos and other visual helps might be helpful to target illiterate and less educated men.

Keywords: Gender, biofortification, nutritional information, willingness to pay, consumer acceptance.

4.1 INTRODUCTION

Worldwide, 2 billion people are estimated to be deficient in key vitamins and minerals, particularly iodine, vitamin A, iron and zinc (WHO, et al., 2007; FAO, WFP and IFAP, 2012; Ezzati et al., 2002; UNICEF, 2017). The most vulnerable groups in terms of micronutrient deficiencies are pregnant women, lactating women and young children (Bhutta et al., 2013; Konje and Ladipo, 2000; WHO et al., 2007). Although there is little information on micronutrient deficiencies and their relationship to gender, there is strong evidence that infant, young child, adolescent, and adult females have significantly worse health and nutrition than males (Smith et al., 2003).

According to the United Nations Development Programme (UNDP, 2015), many of the world's poorest people are women who are also the producers of food and primary caregivers in their households. Women play a critical role in ameliorating the effects of poverty, especially for infants and young children (Darnton-Hill et al., 2005). Successful nutrition interventions to improve women's health and nutrition are necessary to, among others, break the intergenerational cycle of malnutrition and reduce the burden of micronutrient deficiencies (Darnton-Hill et al., 2005). The success and scalability of any nutritional intervention such as biofortification[7] depends on whether this is accepted and consumed by target populations (Meenakshi et al., 2012), especially women. Women are the primary caretakers of children; they prepare the meals and so they influence food purchase decisions and the intra-household distribution of food (HarvestPlus, 2015). One potential solution to tackling intergenerational malnutrition is biofortification.

Despite the significant potential of biofortification in combating micronutrient deficiencies, the evidence on the gendered impact of nutritional information on consumer acceptance of biofortified food is limited. In this study we investigate this issue by analysis consumer acceptance data on iron biofortified beans in Africa (Rwanda) and Latin America (Guatemala), and iron biofortified pearl millet in Asia (India). Even though the data from these studies were analyzed elsewhere (see Oparinde et al. 2015; Banerji et al, 2015 and Perez at al. 2018) in this paper we focus on to

7 Biofortification, the process of breeding and delivering staple food with higher micronutrient content, is one of the potential solutions to micronutrient deficiencies, especially in rural areas of many developing countries where production and consumption of staple crops is high and high micronutrient deficiency rates are extensive (Meenakshi et al., 2012; Saltzman et al., 2013).

understand if there are any gender differences towards the consumer acceptance of biofortified crops and the role that nutritional information might play in these differences. Moreover, a pooled analysis of the three studies is included to produce more general results.

Each one of the three countries included in these studies have relatively high rural populations: 72 % in Rwanda, 68% in Guatemala and 49% in India (World Bank, 2014), Rwanda and Guatemala have the highest per capita bean consumption in the respective continent: 164 g/day for Rwandans (Ferris, 2002) and 34 g/day for Guatemalans (INE, 2006). The state of Maharashtra, where the consumer acceptance study for pearl millet was conducted, has the highest per capita pearl millet consumption in India (Banerji et al., 2015). These three countries are among the 34 countries with the highest burden of malnutrition, including anemia prevalence and Guatemala is the only Latin American country in this group (Bhutta et al., 2013). In Rwanda, 38% of children under 5 years of age and 17% of women of childbearing age suffer from anemia (DHS, 2010), and about half of it is caused by iron deficiency (De Benoist et al., 2008). In Guatemala, the prevalence of anemia is 45% among children under 5 years of age and 26% among women of reproductive age (WHO, 2011). Similarly, 24% of children and 20% of women in rural areas do not have sufficient iron in their diets (MSPS, 2012). In India, the prevalence of anemia is 59% in children aged 6–59 months and 48% in females aged 15–49 years (WHO, 2011). Iron biofortified crops could be a promising way of reducing the prevalence of iron deficiency in these countries. Rwanda ranks first among 81 countries in the Biofortification Priority Index (BPI) for the introduction of iron-biofortified bean varieties, while India ranks second among 55 countries for the introduction of iron-biofortified pearl millet (Asare-Marfo, et al., 2013). Similarly, three different regions are included, as according to Bender (1976), gender differences should be relatively constant in different communities while external factors such as traditions, taboos, etc., may differ at different times and in different communities. Those potential gendered differences in consumer acceptance of iron-biofortified crops and the effect that nutritional information could have on the formation of these preferences are relevant for future breeding, delivery and promotion strategies of iron biofortified crops.

Gracey et al. (1996) and FAO (2012) stated that nutrition interventions programs were more likely to be successful if they considered factors which influenced food choice, as well as those associated with gender differences and their health-related behaviors. Based on different studies (Arganini, et al., 2012; Berbesque, 2009; Marino et al., 2011), the consideration of a gender-specific approach, both in terms of behavior and of psychology, is relevant for addressing successful nutrition issues in research and in policy making.

Women's acceptance of biofortified crops is important for maximizing the potential impact of biofortification on their families' health and livelihoods. Therefore, marketing and messaging on biofortified crops must be targeted at those primary caregivers (HarvestPlus, 2015). Several studies have shown the central role that nutritional information plays in food choice (Du Plessis, 2011; Tepper, et al., 1997) and consumer acceptance of biofortified crops (Benerji et al., 2013; Chowdhury et al., 2011; De Groote et al., 2011; Meenakshi et al., 2012; Oparinde et al., 2014, 2015). Meanwhile, the role of nutritional information on food choice may be different for men compared to women. According to Wardle *et al.* (2004) men prefer taste and convenience over healthy food choices. For men, health is a less important motivational factor when making food choices than it is for women. Other authors stated that men's food choices are influenced by their health beliefs and behaviors, which are defined by a stereotypical socially prescribed masculinity roles. Courtenay (2000) states that: "A man who enacts gender as socially prescribed would be relatively unconcerned about his health and wellbeing and would place little value on health knowledge ... Men won't be interested in learning about health, nutrition or cooking…" This author also stated that this kind of masculine stereotypical behavior is more common in lower socioeconomic groups. Further, other studies have also concluded that men are often less interested in health-promoting behaviors and healthier lifestyle patterns (Courtenay, 1998, 2000; Gough and Conner, 2006; Kandrack et al., 1991; Lonnquist et al., 1992; Roos et al., 2001).

Food choice is a complex human behavior influenced by biological, genetic, social, and cultural factors (Arganini et al., 2012; Bender, 1976). The chemical components and physical properties of the food will affect people's choice using their sensory perceptions. However, perceiving a positive sensory attribute in a food does not always mean that a person will choose to consume that food (Arganini et al., 2012) as there are many other factors (such as gender) that may influence people's preferences (Bender, 1976; Berbesque, 2009; Jensen and Holm, 1999; Sobal, 2005). According to Arganini et al., 2012, the most relevant differences due to gender in food choices in modern Western societies is the relationship between eating habits and health consciousness.

The effect of nutritional information on consumer acceptance of biofortified crops is could be less for men than for women as men usually show resistance to nutritional messages especially in less educated and wealthier groups (Araganini et al., 2012) who feel more ambivalent about healthy dietary choices (Povey et al., 2000; Sparks et al., 2001) and give lower priority to health compared to other considerations, such as taste and convenience, in making their food choices (Steptoe et al., 2002; Wardle and Griffith, 2001). According to Putrevu et al. (2001), men are guided by self-concern and messages that contain agentic sentiments, while women are guided by both themselves and by others, and are easier persuaded with messages that have communal elements. These differences influence how marketing communications are processed and evaluated by men and women.

The gender differences in information processing can be explained by the selectivity hypothesis, which states that under certain conditions, men are more likely to be driven by overall message themes while women are more likely to engage with detailed messages (Putrevu et al. 2001). Based on existing studies (Meyers-Levy and Maheswaran, 1991; Meyers-Levy and Sternthal, 1991; Putrevu et al., 2001), most of the differences in how men and women weigh salient attributes and information sources are better explained in terms of information-processing differences between men and women than in terms of unique interests or knowledge. According to Putrevu et al. (2001), women might benefit more from verbally descriptive messages and men might benefit more from nonverbal reinforcement (e.g. pictures, music, etc.). Women seems to have memory advantages with respect to visual and verbal stimuli in advertisements compared to men who might require nonverbal reinforcement of the verbal product information (Edens and McCormick, 2000).

Based on those aspects, we aim to examine if there are any differences between men's and women's acceptance of iron-biofortified crop varieties and if nutritional information affects female and men preferences for these cultivars. Our objectives are (i) to evaluate if there's any difference between women's and men's sensory evaluation hedonic scores of biofortified varieties; (ii) to analyze if nutritional information motivates differentiated food choices and preferences (WTP) between men and women; and (iii) to determine the effect that nutritional information might have on both women's and men's preferences for iron biofortified crop varieties.

The rest of this papers is distributed as follows. Section 2 presents the details of the methods and data used, the information, models, survey, tools and analyses used. Section 3 describes and summarizes the main results obtained and Section 4 contains a short discussion and the conclusions, including some policy recommendations.

4.2 MATERIALS AND METHODS

4.2.1 Hedonic testing and experimental auctions

Three data sets collected by HarvestPlus[8] and partners to evaluate consumer acceptance of iron-biofortified beans in Guatemala and Rwanda and iron-biofortified pearl millet in India were used (Banerji et al., 2015; Oparinde et al., 2015; Perez et al., 2018) for analysis. Each of these studies collected data on the consumer evaluation of the main organoleptic attributes of iron-biofortified crop varieties using a hedonic rating method (sensory evaluation) and consumer valuation (WTP) using the Becker- DeGroot-Marschak mechanism. In each study, a popular local variety was used as a control. A home use testing (HUT) approach was used in Guatemala and Rwanda and a Central Location Testing (CLT) approach was used in India (Table 4.1).

[8] HarvestPlus is the world leader on biofortification (www.harvestplus.org)

Table 4.1 Sample size and experiment specification by country.

Study location	No. of control group participants	Treatment group participants	Treatments	Product testing setting	Crop tested	Date
Guatemala (San Sebastian Huehuetenango – Huehuetenango): The average market prices for 1 pound (1 pound=0.45 kg) of local bean grains was 5 Quetzales (7.67 Quetzales to 1 USD) at the time of the study.	120	240	1. Control: No information 2. Information once 3. Information three times	HUT	Iron-biofortified bean	August 2013
Rwanda (Northern province - Gakenke): The local unit is in kg with an average market price of 250 to 750 Rwandan francs per kg at the time of the study (USD 1 ≈650 RWF)	127	452	1. Control: No information 2. Information once 3. Information three times	HUT	Iron-biofortified bean	Last quarter 2013
India- Maharashtra (Ahmednagar, Solapur and Nashik): The local unit is in Kg with an average market price of 16 – 20 Rupees per Kg at the time of the study	229	223	1. Control: No information 2.Infomercial (International certification) 3.Infomercial (National certification)	CLT	Iron-biofortified pearl millet	February – March 2012

Source: Author's creation

A total of 360 respondents participated in Guatemala comparing two black bean varieties, one iron biofortified bean variety (super chiva) and the other a traditional local one (parramos). In Rwanda, 572 respondents tested two iron biofortified bean varieties RWV3316 (red) and RWV3006 (white) and a traditional local one Mutiki (red mottled). In the case of Guatemala and Rwanda, respondents were randomly allocated to three treatments: treatment one or the control group, respondents didn't receive any information; treatment two, respondents received nutritional information once; and treatment three, respondents received information three times.

In the case of India, 453 respondents took part in this study in which an iron biofortified pearl millet (HIPM) variety was evaluated against a local pearl miller variety in two presentations, grain and 'bhakri' (a thick flatbread). Apart from treatment 1 or control group (no information) the sample was divided into two treatment groups receiving nutritional information through infomercials only once but differentiated by the certification authority, one international and the other national (local). In India, infomercial was not repeated as was done in Guatemala and Rwanda.

4.2.2 Experimental procedure

After the study was introduced to the community and the participants accepted the invitation to take part in the study, the team collected information on demographic and socioeconomic characteristics. In the case of Guatemala and Rwanda where a HUT approach was used, nutritional information was provided using MP3 players. Some participants received the information once on the first day before the sensory evaluation took place. Other participants received the nutritional information three times on each day before the sensory evaluation and the BDM mechanism were carried out.

In India, participants were presented with both cooked and raw grains of the High Iron Pearl Millet (HIPM) and Local Pearl Millet (LPM) varieties that was to be tested by each participant in turn. There were four sessions on the days of the experiment: the first two were treatment 1, and the last two were treatment 2 (infomercial - international authority) and treatment 3 (infomercial - national authority), whose order was randomized across the 12 locations. The order of presentation of pearl millet types were randomized across participants. Treatment 1 participated in the first two sessions and treatments 2 and 3 participated in the last two sessions in which the infomercial were presented. The control group was interviewed first to minimize potential contamination from treatments with information. The same strategy was followed in the HUT approach in Rwanda and Guatemala.

In India after the demographic and socioeconomic survey, an infomercial was presented on video. There were two versions of the infomercial containing the same information about the nutritional benefits of HIPM, one presented to treatment 2 , showed the HIPM with the international brand (HarvestPlus) and international health certification, the second one presented to treatment 3 showed the HIPM with a local, state-level brand (Samarth) and state-level health authority certification. Each group watched the infomercial at the same time on the same TV, always accompanied by the enumerators to ensure they paid attention to the infomercial and didn't discuss the information with each other at any time during the time they were watching it.

In all the three countries, after responding to the socioeconomic questions, control group participants took part in a sensory evaluation of the LPM and HIPM varieties. The treatment group participants did the same after hearing the message or watching the infomercials.

4.2.3 Sensory evaluation (hedonic test)

In the HUT experiment with iron biofortified beans, participants were given one pound (Guatemala) and 1 kilogram (Rwanda) of each of the varieties being evaluated to cook and consume at home with their household members. One variety was given per visit and there was a day between visits to allow enough time for participants to test each variety. The order of presentation of each variety was randomized across participants and visits. Participants at the HUT evaluated various sensory attributes as taste, color, texture, time of cooking, and a general evaluation of both iron-biofortified and traditional varieties. A 7-point Likert scale was used (7. Like very much, 6. Like moderately, 5. Like slightly, 4. Neither like nor dislike, 3. Dislike slightly, 2. Dislike moderately, 1. Dislike very much).

For the hedonic testing of the pearl millet, participants rated the color and size of the grain and the color, taste, layers and ease of breaking of the 'bhakri' of the two pearl millet varieties one by one, using a Likert scale (ranging from 1-dislike very much, to 5 – like very much). For treatments 1 and 2, the two iron-biofortified pearl millet bean varieties were labeled HarvestPlus/Samarth and LPM; for treatment 1, the two pearl millet types were labeled A and B. The order of presentation of each type of pearl millet sample was randomized across participants.

4.2.4 Becker DeGroote Marschak (BDM) mechanism

To elicit the WTP, a BDM mechanism was implemented in all three studies in this analysis. BDM was chosen because of its suitability in rural settings (Banerji et al., 2013) and its applicability on an individual basis, as it does not require a group of subjects (Lusk and Shogren, 2017is a more efficient method than other experimental auctions (especially in a rural context [De Groote et al., 2011]) and is widely applied in developing countries (e.g. Hoffmann et al., 2009; De Groote et al., 2011; Morawetz et al., 2011). In the BDM mechanism, after participants had tried the products and evaluated the sensory attributes of a variety, each participant placed a bid (b) for each of the products tried. After the bidding, one of the varieties included in each study was randomly selected by the respondent, by picking a slip of paper from a bag containing each variety name, number or geometric figure representing them (e.g. a triangle represented the iron-biofortified variety and a square represented the traditional variety). This selection determined the variety the respondent might purchase. Afterwards respondents picked another slip of paper from another bag containing slips of papers with prices (p) drawn from a distribution (k). The individual got the chance to purchase the variety if $b>p$, and pay price p. If $b<p$, the bidder did not get the chance to purchase. Participants were told that if their bid was higher than or equal to the sales price, they would have to pay the sales price for the bidding variety.

4.2.5 Sample size determination

The sample size for each one of the experiments was determined using an average treatment effect of 5–25%, and a standard deviation (SD) of 11%, based on recent consumer studies (Chowdhury et al., 2011; Meenakshi et al., 2012). An average treatment effect of 5–6% was assumed and a significance level of 5% and a power of 0.8 were used to make the power calculations. Based on that and randomizing treatments at individual level, a minimum of 128 participants per treatment was required for the Rwanda study, 110 participants per treatment for the India study and 120 per treatment for the Guatemala study. In all three studies, participants were randomly selected. The number of participants and its distribution between gender groups is presented in Table 4.2.

Table 4.2 Sample distribution among treatments by study and gender.

Study		**Treatment 1 (Control – No information)**	**Treatment 2 (information once/ HarvestPlus brand and international certification)**	**Treatment 3 (information three times/Samarth brand and local institution certification)**
Guatemala	Total no. of respondents	120	120	120
	Female respondents	55%	77%	65%
Rwanda	Total no. of respondents	127	132	94
	Female respondents	49%	57%	51%
India	Total no. of respondents	229	110	113
	Female respondents	37%	40%	58%
Total sample all countries		476	362	327
	Female respondents	47%	58%	58%

Source: Author's estimation

4.2.6 Test for media homogeneity

A parametric test (ANOVA) or a nonparametric test (Friedman) and Kolmogorov-Smirnov test for validation were used to test for equal means to identify differences between men and women's hedonic valuation for the main organoleptic characteristics and the WTP premium for iron-biofortified crop varieties versus traditional crop varieties within and across treatments. Women and men's hedonics premium ratings and WTP premium were compared between treatments to test the existence of statistical significance differences in preference and acceptance between both gender groups in each treatment.

To compare the sensory evaluation results across the three countries, a standardized liking score was estimated which represents the percentage of liking for each variety for men, for women and for each treatment (Equation 1). The distribution of this standardized liking score is shown in a figure to compare its distribution for each one of the groups. The new liking score was estimated as follows (Equation 1):

$$\% \, Liking = (sum\ of\ score\ for\ all\ attributes / \max score\ for\ all\ attributes) * 100 \qquad (1)$$

The liking score ranks from 1% to 100%, 1% being the lowest (i.e. don't like any attribute at all) and 100% being the highest (i.e. like all the attributes very much).

4.2.7 Difference in difference analysis

A difference-in-differences (DID) model was applied because two differences among the respondents are evaluated, the differences in WTP for iron biofortified and traditional local variety (WTP premium) and how it was influenced by the gender differences.

The model is specified as follows (Table 4.3):

Table 4.3 Differences in different models.

	Traditional variety (Trad)	**Iron biofortified variety (Iron)**	**Difference ($WTP_{premium}$)**
Male (m)	WTP_{tradm}	WTP_{ironm}	$\Delta WTP_{premm}=WTP_{ironm} - WTP_{tradm}$
Female (f)	WTP_{tradf}	WTP_{ironf}	$\Delta WTP_{premf} = WTP_{ironf} - WTP_{tradf}$
Gender Difference	WTP_{tradm} - WTP_{tradf}	WTP_{ironm} - WTP_{ironf}	$\Delta\Delta WTP = WTP_{premm} - WTP_{premf}$

Source: Author's creation

The basic econometric model can be specified as follows (Equation 2):

$$\mathrm{WTP\ it} = \beta 0 + \beta 1\ \mathrm{Git} + \beta 2\ \mathrm{Tit} + \beta 3\ \mathrm{Git\ Tit} + \varepsilon \mathrm{it} \qquad (2)$$

Where:

G_{it} = 1 if *i* is a woman

T_{it} = 1 if the respondent belongs to treatment (t) 2 or 3

G_{it} T_{it} = interaction term, women after treatment 2 or 3

β_0 = intercept

β_1 =gender effect

β_2 = treatment effect

β_3 = effect of the interaction between treatment and gender

ε_i is a random, unobserved "error" term which contains all determinants of WTP_{prem} which our model omits

Gender differences on how information is processed could lead to the effects of the two variables, gender and information, differing systematically across individuals when each one of the varieties was tested, i.e. the distribution of the results for each one of the treatments differed from each other indiscriminately. Based on the work of Abadie (2005) in which differences in observed characteristics created nonparallel outcome dynamics for the treated and untreated groups violating the DID assumption (i.e. that the average outcomes for the treated and control groups would have followed parallel paths over time in the absence of the treatment), an estimation framework was proposed to estimate the average effect of the treatment for the treated.

To include other variables affecting the differences in the difference in the WTP premium between men and women the model was extended in Equation 3 to include the set of socioeconomic variables that may vary between periods for gender reasons:

$$WTPprem = \beta 0 + \ \beta 1.G + \beta 2.T + \beta 3.(G.T) + \ \beta 4.X \ + \varepsilon \quad (3)$$

Based on the former lineal model (Equation 1) and following Cansino and Sanchez (2006), the following DID estimator (E) was proposed for the differences in the WTP premium between men and women (Equation 4)

$$E = \left(\frac{1}{n_1} \sum_{i=1}^{n1} \mathrm{WTP}\, prem\ male - WTPprem\ female \right) - \left(\frac{1}{n_0} \sum_{i=1}^{n0} \mathrm{WTP}\, prem\ male - WTPprem\ female \right) = Effect\ of\ Information \ (4)$$

In which n is the total sample, n_1 is the number of treated respondents (receiving information) and $n_{0\ is}$ the number of respondents in the control group (no information). WTP_{prem} is the differences between the WTP for the biofortified variety minus the WTP for the traditional one. In Equation 2, the first component shows the gender effect on variety choice for treated and the second term shows that effect for control. Equation 3 shows the effect of information under a gender basis.

The Ordinary Least Square (OLS) models were used for the econometric estimation. The natural logarithm of the WTP premium was the dependent variable in order to avoid heteroscedasticity problems. For the pooled regression, the natural logarithm of the percentage change of WTP for the iron-biofortified variety was compared to the traditional one (LN %ΔWTP). This percentage change was used to avoid any problems caused by currency differences.

4.3 RESULTS

4.3.1 Sample characteristics by gender groups

Significant differences were found in the main socioeconomic variables in all countries between men and women (Table 4.4). These differences across gender groups and treatments were considered when interpreting the results, and demographic and socioeconomic characteristics were controlled for in the regression analysis. Some important variables such as income were not included in the analysis because they were not enumerated in all the three studies, in this case, all land owned was used as proxy of wealth.

Table 4.4 Participants and household level socioeconomic characteristics by gender group.

Variable	Definition	India		Guatemala		Rwanda	
		Mean/(S.D.)		Mean/(S.D.)		Mean/(S.D.)	
		Men	Women	Men	Women	Men	Women
Information	1 = if nutritional information was received; 0 = otherwise	0.55 [c]	0.43 [c]	0.64	0.64	0.57 [c]	0.71 [c]
Repetition	1 = if nutritional information was received three times; 0 = otherwise	N/A	N/A	0.28	0.25	0.35	0.32
Age	Respondent's age in years	40.16 (11.74)	39.50 (13.02)	44.72[a] (16.58)	43.03[a] (14.79)	38.89[c] (12.45)	33.63[c] (9.94)
Education (years)	No. of years of formal education	9.81[c] (4.83)	6.95[c] (5.19)	3.74[b] (3.05)	3.24[b] (3.19)	4.10[b] (2.93)	3.45[b] (3.56)
Literacy	Literacy (1 = respondents knows how to write and read; 0 = otherwise)	0.90 [c]	0.74 [c]	0.56 [c]	0.47 [c]	0.81 [c]	0.63 [c]
Household size	Number of members in the household	6.62[c] (4.08)	5.25[c] (2.84)	6.07 (2.37)	5.88 (2.52)	4.70[b] (1.89)	4.47[b] (1.78)
Area (ha)	All land area owned by the respondent (ha)	2.36[c] (3.23)	1.05[c] (1.05)	0.67[a] (0.73)	0.66[a] (1.23)	0.18[c] (0.27)	0.12[c] (0.19)
Grain holder	Grain of beans/pearl millet at home when the study took place (yes=1)	82.94	80.82	66.40	63.20	34.90[c]	26.23 [c]
Iron	1 = respondent has listened to messages about food biofortified with iron before the study; 0 = otherwise	0.21	0.24	0.09 [b]	0.13 [b]	0.49 [c]	0.28 [c]
Anemia	1 = respondent has heard about anemia before the study; 0 = otherwise	59.30 [b]	68.55 [b]	0.54	0.55	0.61	0.55
Variety order (varorde)	1 = respondent tested the iron beans forst; 0 = otherwise	3.49[c]	3.24 [c]	4.71[a]	4.79[a]	4.37	4.35

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level

Source: Author's creation

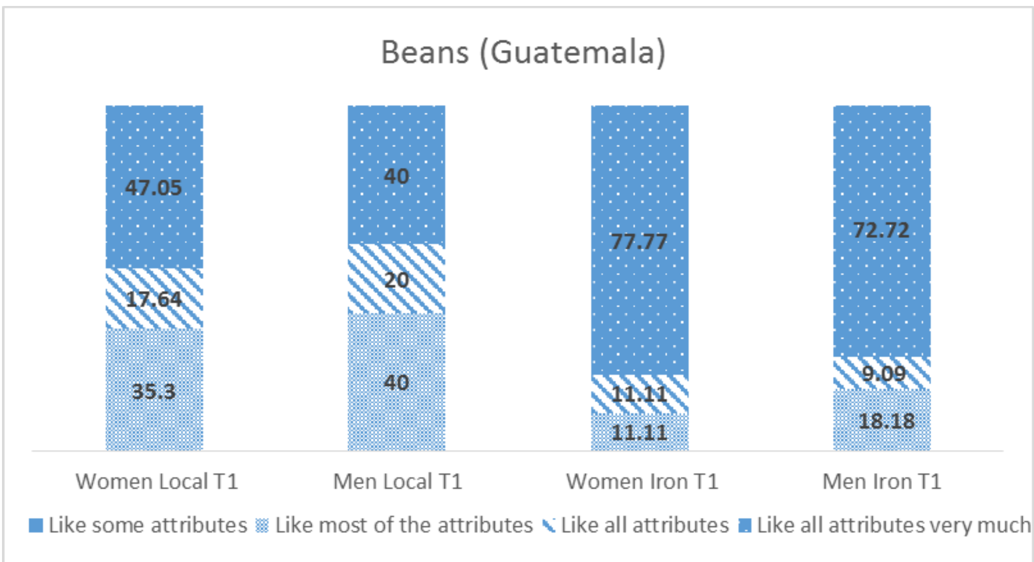
4.3.2 Sensory evaluation

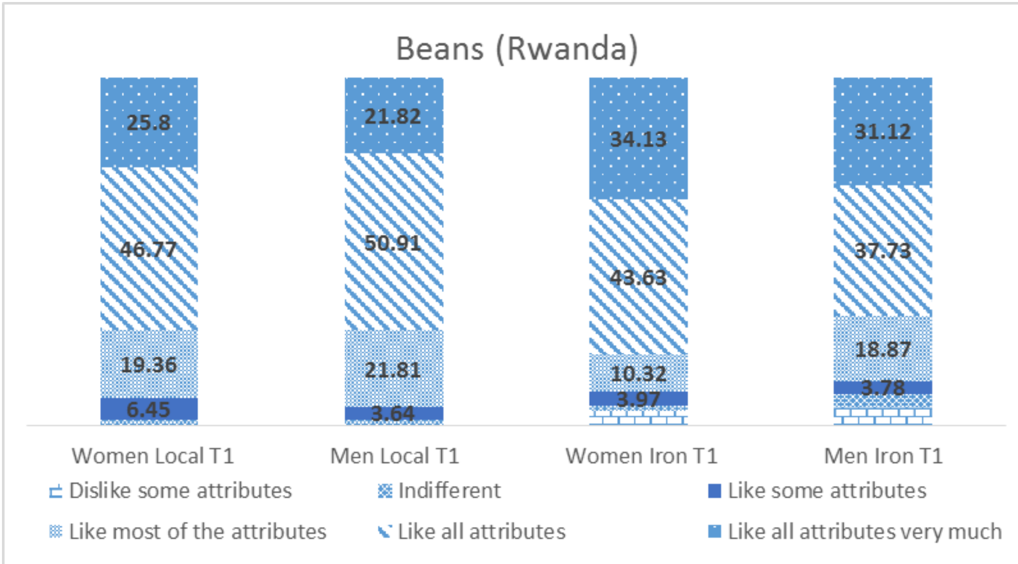
By comparing the distributions of the standardized liking scores by gender, treatment and variety, the differences in how men and women evaluated each variety and the impact that information and repetition could have was analyzed. Figure 4.1 shows the percentage of respondents by the range of percent liking (Eq. 1). According to the range of percent liking, respondents were classified in 6 groups (dislike some attributes, indifferent between both varieties, like some attributes, like most of the attributes, like all attributes and like all attributes very much). Based on the standardized liking scores, respondents were distributed in each group. Those distributions are shown in the following figures. The differences in the distribution were tested using parametric and non-parametric tests, depending on the result of the test of normality. The null hypothesis that there are no differences in the distribution was tested. Post-hoc analysis was carried out to determine among which distributions the differences appeared.

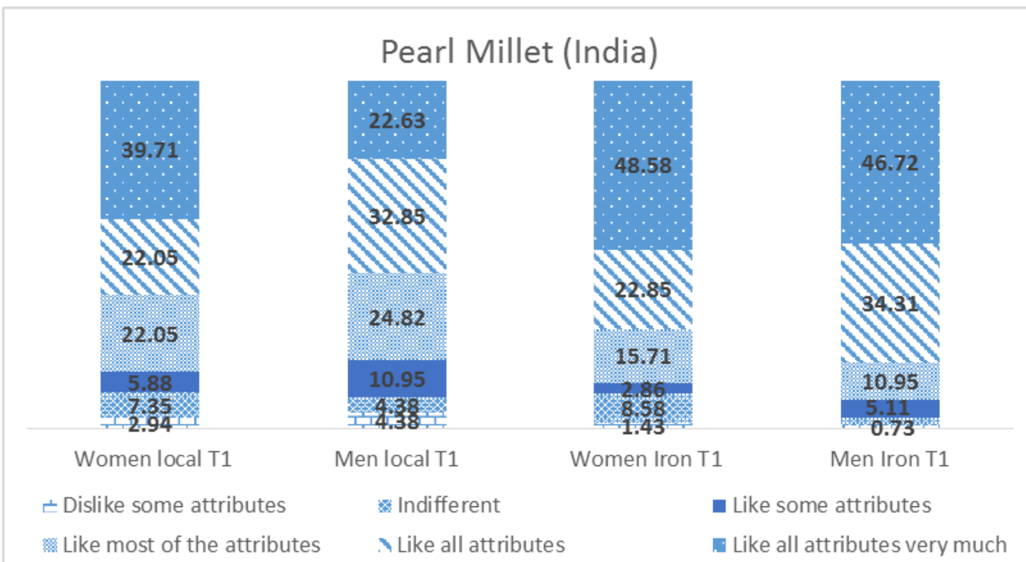
Differences in how men and women evaluated (or liked) iron biofortified and local varieties differently.

To determine if men and women evaluated iron biofortified varieties differently, the distribution of the percent liking for both varieties and gender groups in the control group (no information (T1)) in Guatemala, Rwanda and India was evaluated (Figure 4.1). In Guatemala, more than 70% of the respondents, regardless of their gender, like all iron biofortified variety attributes very much, meanwhile for the local variety the higher proportion of the respondents are concentrated in the like most of the attributes group, 35% for women and 40 % for men. In Rwanda, in average half of the respondents are in the "like all attributes group" for the local variety, meanwhile for the iron biofortified varieties the distribution change being the group of "like all attributes very much" the only liking group which grew, reaching more than 30% of the respondents in both gender groups. In India for the local variety the higher proportion of female respondents (40%) are in the "like all attributed very much" and the higher proportion of men (33%) are in the "like all attributes" group. For the iron biofortified variety this last liking group reaches almost 50% of the respondents. With a p-value of 0.30, 0.74 and 0.91 in the Friedman test for India, Rwanda and Guatemala respectively, a possible evidence for differences among the liking distributions in the control groups was found, showing that men and women could evaluated iron biofortified and local varieties differently when no nutritional information was received. In all the three countries, women and men show a higher proportion of respondents on “like all attributes too much” for the iron biofortified varieties than for the local varieties but in all cases, women proportion in top liking score group is higher than men’s. In Guatemala and India, a significant higher preference for the iron biofortified variety compared to the local variety in both gender groups was observed. In Rwanda the tendency is the same, but the difference is not significant. Those results shows some potential evidence of a higher preference for the iron biofortified variety over the local one when no nutritional information is provided.

Figure 4.1 Distribution of sensory liking by gender groups for iron biofortified and local varieties in control groups (no information).





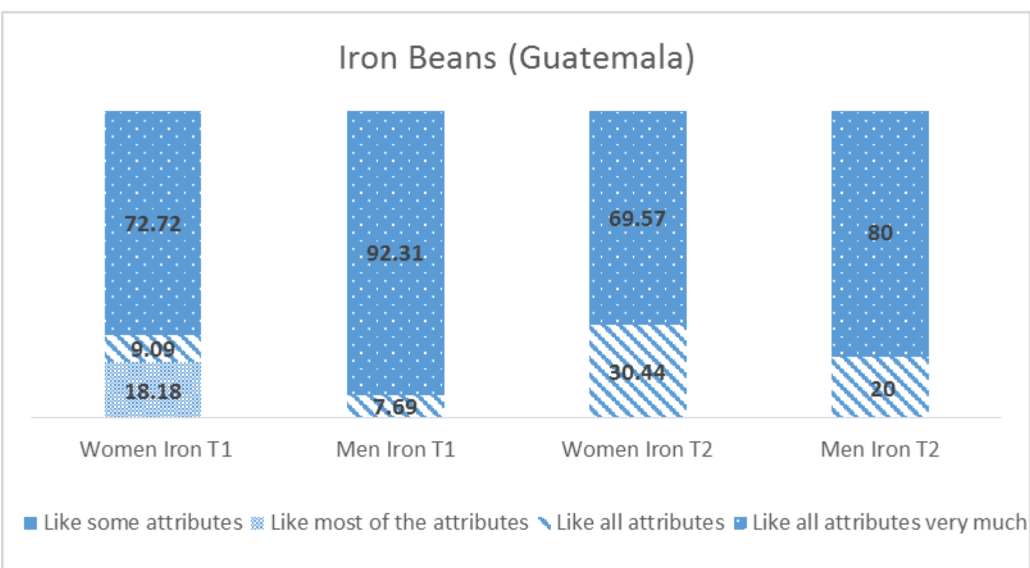


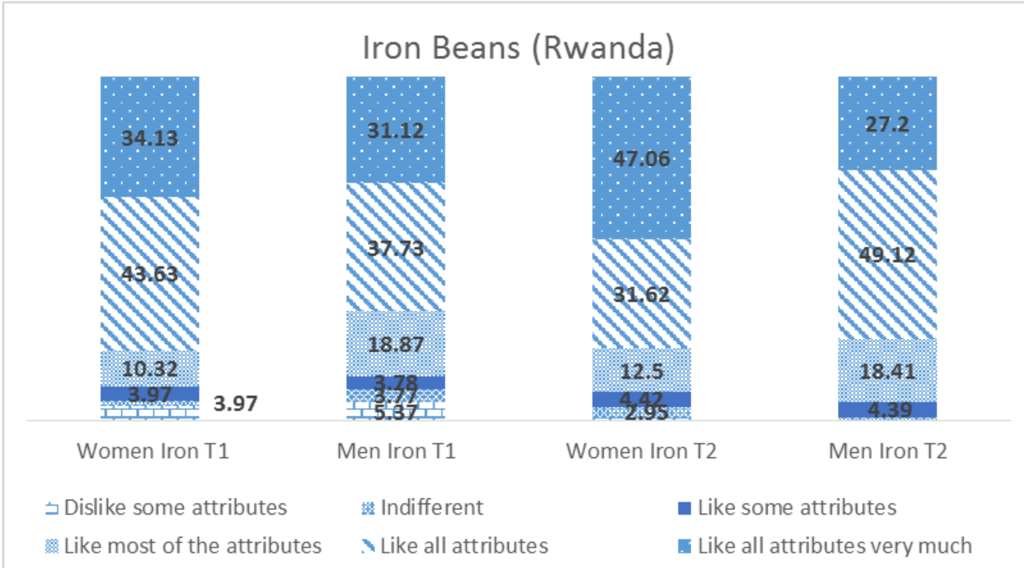
Source: Author's creation

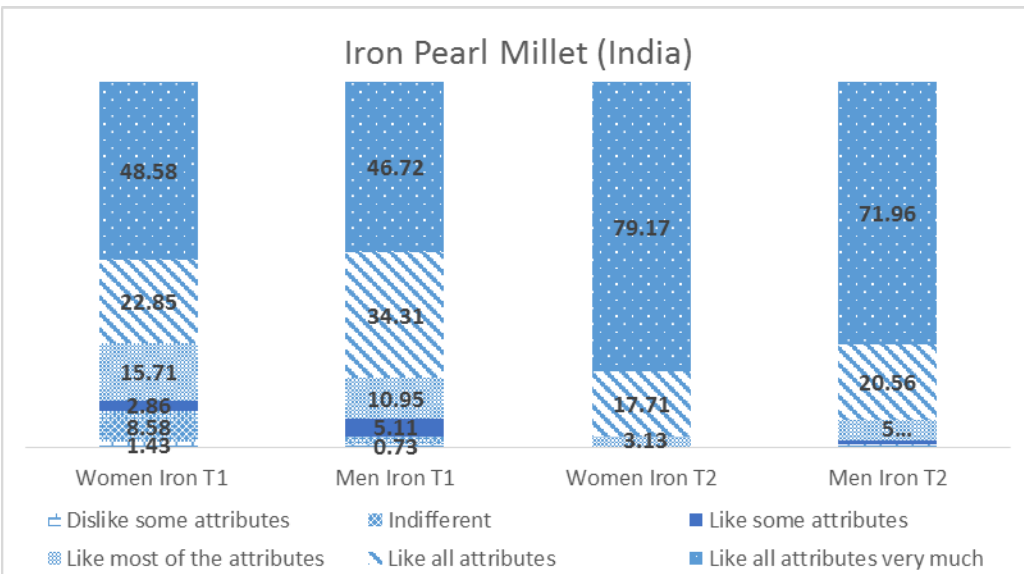
Differences in the impact of nutritional information on sensory attribute liking by men and women

To determine the impact of nutritional information on liking by men and women, the distributions of the percent liking for iron biofortified varieties on treatment 1 (no information –T1) and 2 (information once -T2) were compared for both gender groups. Figure 4.2 shows these distributions. In Guatemala, 72% and 92% of women and men respectively are in the "like all attributes very much" group for treatment 1, this proportion decrease to 70% and 80% in both gender groups in treatment 2. In Rwanda the highest proportion of respondents in treatment 1 are in the “like all attributes”, 43% of women and 37% of men. In treatment 2, the proportion of women in the “like all attributes very much” increase to almost 50%, meanwhile the proportion of men in this group decrease but increase in the following groups, showing that all the male respondents are redistributed in the top liking groups when nutritional information was received. Similar tendency was observed in the case of men in Guatemala. In India, almost 50% of all respondents are in the “like all attributes very much” group when no information was received, but in treatment 2, this proportion increase to almost 80% of women and more than 70% of men. With a p-value in the Friedman test of 0.30 in India, and 0.97 in Rwanda and Guatemala, potential differences on the impact of nutritional information between men and women are shown. In Rwanda and India, women preferred iron biofortified varieties more than men when nutritional information was received once. Guatemala is the exception, although this difference is not significant. These results agree with the literature which states that women are more sensitive to health and nutritional messages than men (Arganini et al., 2012) and that for men health related issues were less motivational factors for consuming iron-biofortified crop varieties than for women (Wardle et al., 2004). This was especially clear where women received information about the benefits that the iron biofortified varieties could have on their children’s health.

Figure 4.2 Distribution of sensory liking by gender groups for iron biofortified varieties in control and information once groups.







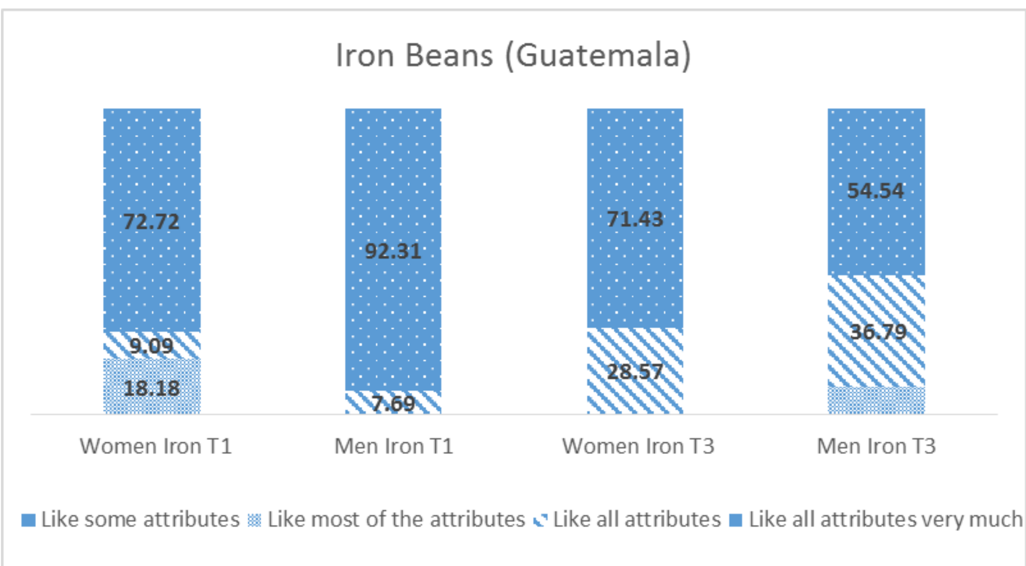
Source: Author's creation

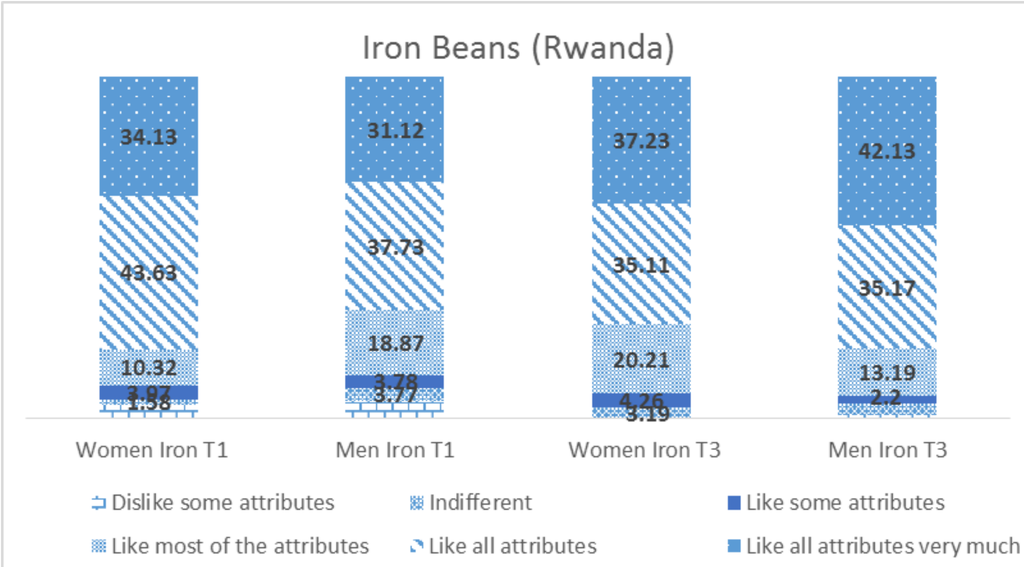
Differences in the effect nutritional information repetition on sensory attributes' liking by men and women

To evaluate the differences in liking between men and women when nutritional information has been repeated, the percent liking distribution of both gender groups and for no information (treatment 1 – T1) and information three times (treatment 3 – T3) was compared. For women in

Guatemala, respondents were redistributed in the 2 highest liking groups when nutritional information was repeated, showing a positive impact of information repetition on women liking for the iron variety. The opposite was for men, the proportion of male respondents in the top group “like all attributes vary much” decreased significantly when nutritional information was repeated. In Rwanda, the proportion of respondents in the highest liking groups increased when nutritional information was received, but that increase was no statistically significant in both gender groups. In the case of the iron biofortified bean variety in Rwanda and Guatemala (Figure 4.3), significant differences were found among the distributions (Friedmans’ p-value of 0.91 and 0.87 respectively), showing that nutritional information repetition had different level of impact on liking for men than for women. In Rwanda, women’s and men’s preference for the iron biofortified variety was higher when nutritional information is repeated, but men’s liking is slightly higher than women’s. In Guatemala, women liked the iron biofortified bean variety more than men. Both results are in line with Edens and McCormick (2000), who stated that men might benefit from nonverbal reinforcement or repetition of the health or nutritional verbal information to have a significant impact on them.

Figure 4.3 Distribution of sensory liking by gender groups for iron biofortified varieties in control and information repetition groups.





Source: Author's creation

4.3.3 Economic evaluation (willingness to pay)

Table 4.5 reports WTP premium expressed on percentage differences[9] for both women and men across treatments by country. This percent difference on WTP is estimated as follows (equation 6):

$$\%WTPpremium = \left[\frac{(WTP\ ironbiofortified\ variety - WTP\ local\ variety)}{WTP\ Local\ variety}\right]x\ 100 \qquad (6)$$

The results show that in all cases, the WTP for the iron biofortified variety was higher than the WTP for the local one for both gender groups, in all treatments and countries, although those differences are not statistically significant in most of the cases.

In within treatment comparisons, positive and statistically significant differences were only found in the WTP premium for the iron biofortified variety for women versus men in treatment 1 in India.

For women in the across treatment comparison, statistically significant differences were only found when comparing Treatment 1 (no information) with Treatment 2 (information) in India, which shows the positive impact that nutritional information has on women's acceptance. For men, statistically significant differences were also found when comparing Treatment 1 and Treatment 2

[9] WTP premium = WTP iron-biofortified variety – WTP traditional variety

in India and Guatemala, showing that nutritional information had a positive impact on men even when it was received just once.

Table 4.5 Percent difference in WTP premium for iron biofortified by gender and treatments.

	India	Rwanda	Guatemala
	Percent difference in WTP (Traditional variety vs. Iron variety)		
Women			
No information	6.2%	4.78%	6.57%
Information once	34.72%	6.46%	7.89%
Information three times	N/A	10.72%	5.53%
Men			
No information	13.96%	2.82%	2.68%
Information once	34.81%	3.52%	9.33%
Information three times	N/A	5.58%	7.13%
Within treatment comparison	Premium/Discount (% differences)		
T1 (women vs. men)	-83.44% [b]	69.32%	144.86%
T2 (women vs. men)	2.99%	98.81%	-15.46%
T3 (women vs. men)	N/A	92.17%	-22.41%
Across treatment comparison			
Women (T1 vs. T2)	-94.36 %[c]	-26.07 %	-16.68%
Women (T1 vs. T3)	N/A	-55.44%	18.81%
Women (T2 vs. T3)	N/A	-39.72%	42.59%
Men (T1 vs. T2)	-64.95% [c]	-13.19%	-71.23% [a]
Men (T1 vs. T3)	N/A	-49.92%	-62.35
Men (T2 vs. T3)	N/A	-41.73%	30.86%

NA – Not applicable c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level

Source: Author’s estimation

4.3.4 Econometric analysis

We estimated the impact of gender, nutritional information and its repetition on the WTP premium for the iron biofortified varieties. These estimates were done for each of the countries and for the pooled one (i.e. all three countries together) to evaluate any potential country specific effect or to find out if the results could be pooled regardless of the country or region.

To validate some of the hypothesis found in the literature, the econometric models were control by country (external factors), education, information and repetition and their interaction with gender. The interaction with education is included to validate the hypothesis stated by Araganini et al. (2012) that men usually show skepticism and resistance to nutritional messages especially in less educated groups. Other interactions were dropped because of their high correlations showed when variance inflation factor test was conducted to check for potential multicollinearity. Only those socioeconomic variables, which are not strongly correlated were included.

Table 4.6 reports the estimates from the models estimated for each one of the countries and also the pooled data.

Table 4.6 Determinants of WTP premium for 1 kg of iron–biofortified variety: Ordinary least square

	India (Dependent variable: LN (WTP premium)	Rwanda Dependent variable: LN (WTP premium)	Guatemala Dependent variable: LN (WTP premium)	Pooled (Dependent variable: LN %ΔWTP)
Guatemala (yes=1, otherwise 0)	N/A	N/A	N/A	0.27[a] (0.06)
Rwanda (yes=1, otherwise 0)	N/A	N/A	N/A	0.36[a] (0.01)
Information (1 = if nutritional information was received; 0 = otherwise)	0.09 [b] (0.03)	0.21 [b] (0.11)	0.25[a] (0.31)	0.17[b] (0.09)
Repetition (1 = if nutritional information received three times; 0 = otherwise)	N/A	0.05 [a] (0.01)	0.00 (0.09)	0.10 (0.00)
Gender: 0 = woman, 1 = man	-0.07 (0.02)	0.09 (0.01)	-0.20 (0.12)	-0.18 (0.07)
Education (years)	0.07[b] (0.11)	0.09[a] (0.02)	0.11[b] (0.06)	0.10[c] (0.12)
All land owned	0.17 (0.05)	-0.10 (0.07)	-0.19 (0.19)	-0.15 (0.05)
Gender x information	-0.04 [a] (0.00)	-0.16 (0.11)	-0.10[c] (0.11)	0.05 (0.01)
Gender x repetition	N/A	0.22[a] (0.10)	0.05[a] (0.00)	(0.07)[a] (0.01)
Gender x education	0.03 (0.10)	0.17[a] (0.05)	0.02[b] (0.11)	0.17[a] (0.09)
Gender x education x information	0.10 (0.01)	0.03 [a] (0.07)	0.18 (0.09)	0.09 (0.01)

C = statistically different at 1% significance level; b = statistically different at 5% significance level; a = statistically different at 10% significance level

Table 4.6 (*Cont.*) Determinants of WTP premium for 1 kg of iron–biofortified variety: Ordinary least square.

	India (Dependent variable: LN (WTP premium)	**Rwanda Dependent variable: LN (WTP premium)**	**Guatemala Dependent variable: LN (WTP premium)**	**Pooled (Dependent variable: LN %∆WTP)**
Gender x education x repetition	N/A	0.16^{c} (1.21)	0.32^{b} (0.18)	0.07^{b} (0.11)
_cons	0.14^{b} (0.07)	0.12^{b} (0.17)	-0.02 (0.22)	0.33 (0.78)
Number of observations	449	708	358	1033
Prob >F	0.02	0.00	0.00	0.00
R^2	0.37	0.44	0.52	0.48
Adjusted R^2	0.11	0.15	0.09	0.17
Breusch-Pagan Test (Prob > chi2)	0.23	0.33	0.33	0.27
White test (p value)	0.55	0.49	0.37	0.18

C = statistically different at 1% significance level; b = statistically different at 5% significance level; a = statistically different at 10% significance level

Source: Author's estimation

According to the regression results reported in Table 6, those men receiving information once and having more years of education have a higher WTP premium for the iron biofortified variety than women with same education or than other men not receiving nutritional information in the three countries. In India this difference in the WTP premium is US$ 0.26, in Rwanda US$ 0.45 and in Guatemala US$ 0.26. Those results show that nutritional information had a positive impact on more educated men who were probably more aware of health and nutrition themes than less educated ones (Araganini et al., 2012). This is the case even for agricultural products in which the producers, mostly men, were more interested in their agronomical and market performance than in the nutritional impact that those products might have.

In the case of information repetition the results are similar than those with information once. In Rwanda and Guatemala, those men receiving nutritional information repetition and with more years of education have a higher WTP premium for the iron biofortified varieties, in Rwanda this difference is US$ 0.64 and in Guatemala US$ 0.48. Those results show that repeated information had a positive significant impact on more educated men, which are according to the results found in the existing literature in which some authors stated that men respond better to this kind of information when they have more education or have received any kind of reinforcement compared to women (Edens and McCormick, 2000). Education alone also has a positive impact in all regressions. It is possible that the higher the education level, the higher the awareness of health and nutritional issues. However, income didn't have any significant impact on WTP premium.

In the pooled regression country variables had a significant positive impact on the percentage change of WTP premium, this shows a potential impact of external factors such as culture, taboos, and traditions, which differed from one region to the other, as stated by Bender (1976). Then in Guatemala and Rwanda have a higher WTP premium than in India. According to this regression results, nutritional information and education has a positive impact on WTP premium, being this impact even higher in more educated men. In the case of information repetition, it has a positive impact on men and especially in those with more years of education. Those results are in the same direction than those found in the countries regressions.

4.4 CONCLUSIONS

In this paper, we showed that nutritional information and its repetition had different impact on women and men's acceptance of iron biofortified crops in three developing countries: India, Rwanda and Guatemala. In each one of these three countries a BDM mechanism was implemented to elicit the willingness to pay for each variety tested and a hedonic testing method was used to evaluate iron biofortified bean in Guatemala and Rwanda and iron biofortified pearl millet in India vis a vis conventional varieties. Pooled data represented 1,165 participants, about half (54%) were women.

Biofortification with iron doesn't change any of the visible attributes of the crop. Therefore iron biofortified foods can be considered to be credence goods, that is, consumers don't know the real nutrition value of these crops. The value given by each consumer may vary by gender. Various studies have evaluated the role of nutritional information on consumer acceptance of different biofortified crops. Information received once versus those received three times, verbal versus visual information, gain frame information versus loss frame information have been evaluated, but none have evaluated the different roles that gender may play in the impact that this information could have on consumer acceptance.

Nutritional information processing and food choices can be different for men compared to women. Men's food choices can be prejudiced by stereotypical masculinity roles, making them less interested in health and nutritional matters. Men, especially those with more education, need informational reinforcement on issues related to health and nutrition. Gender differences in information processing may also have played an important role in the differences in how men valued biofortified crops compared to women. The hypothesis that men's WTP premium for an iron biofortified variety compared to a traditional one was lower than the women were tested.

Based on the results of the comparison of the distributions of the liking scores by gender, differences in how men and women evaluated iron biofortified varieties and differences in the impact of nutritional information and its repetition in both gender groups were found. Those results are according to evidence in the existing literature (See Arganini *et al.,* 2012) which states that women are more sensitive to health and nutrition messages than men and that men require repetition of this kind of information in order for it to have a positive impact.

Although the WTP for the iron biofortified variety was higher than the WTP for the traditional variety and information and repetition had a positive impact on the WTP premium, no significant differences were found between men and women. Meanwhile, the results of regression analysis corroborate the theory, revealing that nutritional information has a higher positive impact on women than on men, and its repetition tends to have a positive impact on more educated men's.

Based on the results, to give nutritional information and its repetition could be a good strategy to increase consumer acceptance towards the biofortified crops, especially among more educated men and households. As this segment of male population usually belongs to the wealthiest households which generally has better nutritional conditions than the others, this promotion strategy of the biofortified crops could be misdirected. Biofortification must impact mainly, but no only, those poor household incapables to fulfill their nutritional requirements and/or to have limited access to health and nutritional programs as supplementation and industrial fortification. Those target households are usually characterized by illiterate or low educated household heads. Then, this information and repetition strategy must be complemented by other strategies targeting low educated men and women as pictures, videos, etc. By using this complemented strategy a wider range of population will be reached specially among those in which biofotification must be focused.

These results are essential for future consumer acceptance research on health and nutritional interventions such as biofortification and the role that information might play in its acceptance. Gender context should be taken into consideration in further evaluations and in promotion strategies for biofortified crops. Further research should be conducted to validate another hypothesis on how women and men reacted to visual and nonvisual messages, since existing evidence suggests that men are guided by messages that contain agentic sentiments while females are guided by both self and others, and are more persuaded with messages that contain communal elements.

4.5 References

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5. ROLE OF RESPONDENT'S MARKET PARTICIPATION IN CONSUMER ACCEPTANCE TOWARDS SEEDS AND GRAIN OF AN IRON-ENRICHED BEAN VARIETY IN GUATEMALA

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The article in this chapter was submitted on *CESifo Economic Studies Journal* on August 30th 2018.

ABSTRACT

This study introduces respondent's market participation on the analysis of the consumer acceptance of biofortified beans. Biofortification is a complementary strategy to fight iron deficiencies mainly in populations who usually produce and consume their own beans. As most of biofortification's target population and consumer acceptance studies participants are farmers who produce and consume their own food, their evaluation as producers hasn't yet been evaluated. The evaluation will depend on the respondents' market participation. The aims of this study are: (i) to compare the consumer acceptance results of two different studies, one evaluating grain and the other evaluating seed of an iron-enriched bean variety; (ii) to analyze how market participation influences respondents' preferences and willingness to pay (WTP); and (iii) to evaluate how agronomic and sensory evaluation are defined by market participation. Two data sets from studies evaluating the consumer's acceptance of an iron-enriched bean variety, one testing seed, conducted with 360 households in Huehuetenango in 2013 and the other testing grain, with 322 beans producers in 8 departments in Guatemala, were used for this purpose. Results indicate that there are differences in how respondents valued the iron-enriched bean variety attributes, and this depended on if a seed or grain was tested and on respondents' market participation. The link between market participation and the acceptance of the iron-enriched bean variety was validated by an econometric analysis. Results are relevant for future research on consumer acceptance of biofortified crops, identifying if crops or seed must be tasted based on the respondents' profile.

Keywords: acceptance, beans, biofortification, consumers, grain, market participation, producers, seed

5.1 INTRODUCTION

According to the Inter-American Development Bank (IDB) (IDB, 2016), Guatemala's main nutrition problem is the poor quality of its diet and eating practices, resulting in half of its children under the age of 5 suffering from anemia and stunting. A report from the World Bank (World Bank, 2015) stated that limited access to nutritious and diverse diet is a problem reflected in high rates of anemia in the country. The rural Guatemalan diet is based mainly on maize (tortillas) and beans with an average daily intake of 423 g/day and 58 g/day, respectively. Beans are the main source of protein in rural Guatemala and their consumption is higher in rural and poor areas (Aldana, 2010). Most of the beans consumed in the country are produced by small farmers; a total of 86.59% of all bean production units are 7 ha or less, and most are self-consumed by farmer families, making this country a suitable candidate for the introduction of biofortified beans. Biofortification, i.e. the process of breeding and delivering staple food crops with higher micronutrient content (Qaim, Stein, and Meenakshi, 2007; Bouis et al., 2011; Saltzman et al., 2013), could prove to be a cost-effective and sustainable strategy, especially in rural areas of developing countries such as Guatemala, where production and consumption of staple crops is high and micronutrient deficiency rates are low (Asare Marfo et al., 2013). Biofortification mainly targets the rural poor, who produce and consume staple food crops in significant quantities, and who may not have access to other nutrition interventions such as fortification (Birol et al., 2015). According to Meenakshi (2002), to make the biofortification a successful and cost-effective strategy farmers and consumers must accept the new variety and make it an important part of what they produce and consume.

Several studies have been conducted in developing countries to investigate consumer acceptance of biofortified food or grain (see for example, Banerji et al., 2013 for vitamin A-enriched maize in Ghana; Chowdhury et al., 2011, for vitamin A-enriched orange sweet potato in Uganda; Talsma et al., 2013 for vitamin A-enriched cassava in Kenya; Banerji et al., 2015 for iron-enriched pearl millet in India and Oparinde et al., 2015, for iron-enriched beans in Rwanda), but none have evaluated the acceptance of biofortified seed. For those bean producers who are also target consumers of biofortified beans, more accurate estimates of their acceptance of the biofortified varieties should be estimated. For them, the driving forces defining their preferences for and acceptance of these varieties are defined by their acceptance of the sensory attributes (e.g. color, taste, time of cooking, etc.) or the agronomic attributes (e.g. yield, drought resistant, etc.), or a combination of both. The most relevant attributes for each respondent were related to their level of market participation. For respondents testing seed with high market participation, (i.e. producers selling a high proportion of their production in markets), agronomic attributes might be more relevant for producers who sell most of their produce in markets, as achieving good production in terms of quantity and quality according to market requirements is their priority. For seed testers with low market participation, who consume most of what they produce, their evaluation was based on sensory attributes, and on what their and their families preferences were. Then, market participation might define how consumer ranked sensory and agronomic attributes when seed or grain was tested.

In this paper, we compared two data sets from studies that evaluated consumers' acceptance of an iron-enriched bean variety known as Superchiva in Guatemala, which contain 50% more iron than the traditional ones. The first of these studies was conducted in the northwest of Guatemala where 360 bean consumers (87% of them who were also bean producers) received the grain to cook and taste at home. Only consumer attributes (sensory and culinary) were tested. The second was an acceptance study of the same variety conducted with bean producers in different regions of Guatemala. In this study farmers received the seed, planted, harvested, and tasted the beans at home. Agronomic and consumer attributes were tested.

The aim of this research study is to determine if there was any difference in consumer acceptance of biofortified beans between those respondents receiving seed and those receiving grain, based on their market participation. The aims of this study are: (i) to compare the consumer acceptance results of two different studies, one evaluating grain and the other evaluating seed and grain of an iron-enriched bean variety; (ii) to analyze how market participation influences respondents' preferences and WTP; and (iii) to evaluate how agronomic and sensory evaluation were defined by market participation.

5.2 METHODOLOGY

In the consumer acceptance studies of biofortified crops carried out to date, rural consumers received the grain they tried either through a home testing or central location approach. None of them received seed and consumed and evaluated the grain they harvested. The producer and market relation perspectives haven't yet been evaluated. Only in one case in Guatemala, producers received biofortified seed, then agronomic, organoleptic and culinary attributes were tested. The two studies included in this analysis will be described next.

5.2.1 The elicitation and Data Collection Method

The studies conducted in rural Guatemala evaluated the acceptance of an iron-enriched bean variety known as Superchiva.[10] In both studies, sensory hedonic testing and WTP methods were used. Table 5.1 summaries the main aspects of both studies.

Table 4.7 Key aspects of consumers' acceptance studies towards an iron-enriched bean variety in Guatemala

Study	Sample size	Region	WTP Elicitation mechanism	Attributes evaluated
Consumer acceptance of an iron bean variety in northewest Guatemala: The role of information and repeat messaging.	360 rural consumers (87% beans producers)	Municipality of San Sebastian Huehuetenango (Northwest Guatemala)	Becker–DeGroot-Marschak (BDM) auction-like mechanism	Raw bean color, raw bean size, bean taste, cooking time, cooked bean thickness, and the overall evaluation
Early acceptance and adoption of an iron bean variety in west and east Guatemala	332 bean producers	98 municipalities in 8 departments	Respondents were directly asked about their WTP	Time of cooking, bean taste, cooked bean color, cooked bean size, soup thickness, overall evaluation

Source: Author's creation

Hedonic or consumer testing seeks to measure the personal preference for or acceptance of consumers for a product, product idea or specific product characteristics (Meilgaard et al., 2006; Tomlins et al., 2007, Birol et al., 2015). The testing methods commonly used in hedonic testing

[10] Superchiva has 74 ppm of iron, the traditional beans varieties have 50-55 ppm of iron

include difference tests (which determine which product preferred over another), measures of acceptance or liking using a liking/hedonic scale (Birol et al., 2015)

Different elicitation techniques may be used to obtain the WTP for a product. Economic valuation methods such as experimental auctions, auction-like mechanism (e.g. Becker-DeGroot Marschak mechanism [BDM]) and revealed choice experiment are the most commonly used. In the two first, real products are offered for sale and participants expend real money to purchase them (Birol et al., 2015).

5.2.2 Biofortified grain acceptance

The first of this studies, "Consumer acceptance of an iron-enriched bean variety in northwest Guatemala: the role of information and repeat messaging" (Pérez et al., 2018), conducted in August 2013 evaluated the consumer acceptance of this variety using an experimental auction mechanism in northwest Guatemala. The role of information and its repetition were also evaluated. In this study, two black bean varieties were tested. One iron-enriched bean variety (Superchiva) and the most commonly consumed traditional variety in the region (Parramos) were compared. Data was collected using the home use testing (HUT) method, in which 360 randomly selected rural households received 1 lb of grain of both bean varieties for two days (one variety on each day, in a random order) to cook and eat at home. Based on the average household size and demographics and information on bean quantity consumed per person in the region, 1 lb was calculated to be sufficient for an average household's breakfast and lunch consumption. Each consumer had a chance to experience and to evaluate the following sensory and cooking attributes: raw bean color, raw bean size, bean taste, cooking time, cooked bean thickness, and the overall evaluation. Each attribute was evaluated on a 7-point Likert scale ranging from 1 (dislike very much) to 7 (like very much) (other levels were: 2: Dislike, 3: Dislike a little, 4: Neither like nor dislike, 5: Like a little, 6: Like).

After the study was introduced to the community and the participants accepted the invitation to take part in the study, the team collected information on demographic and socioeconomic characteristics. Nutritional information was provided using MP3 players. Some participants received the information once on the first day before the sensory evaluation took place. Other participants received the nutritional information three times on each day before the sensory evaluation and the BDM mechanism were carried out the last day for WTP elicitation. In the BDM mechanism, after participants had tried the products and evaluated the sensory attributes of a variety, each participant placed a bid (b) for each of the products tried. After the bidding, one of the varieties included in each study was randomly selected by the respondent, by picking a slip of paper from a bag containing each variety name, number or geometric figure representing them (e.g. a triangle represented the iron-enriched variety and a square represented the traditional variety). This selection determined the variety the respondent might purchase. Afterwards respondents picked another slip of paper from another bag containing slips of papers with prices (p) drawn from a distribution (k). The individual were allowed to purchase the variety if b>p and pay price p. If b<p, the bidder was not allowed to purchase. Participants were told that if their bid was higher than or equal to the sales price, they would have to pay the sales price for the bidding variety.

5.2.3 Biofortified seed acceptance

The second study, "Early acceptance and adoption of an iron-enriched bean variety in west and east Guatemala" (Pérez et al., 2016) was conducted in 2014/15. In this study, Guatemala's Ministry of Agriculture (MAGA) and the Inter-American Institute for Cooperation on Agriculture (IICA) implemented a project in which seed of the iron-enriched bean variety (Superchiva) was distributed in 12 departments in Guatemala. In total 1,050 bean producers received seeds in 98 municipalities. Because of the severe drought in the region in 2014, many of these beneficiaries lost their crops. After that, the beneficiaries' sample was reduced to 540 distributed in 8 departments and 98 municipalities. Only 332 of these were surveyed. The distribution of beneficiaries by region was similar, 168 in the west region (Huehuetenango, Quezaltennago, Quiché y San Marcos) and 164 in the east region (Alta Verapaz, Chimaltenango, Jalapa, Sololá).

Seed was distributed in the period April–August 2014 but the beneficiaries were surveyed in April 2015. The survey included questions about the beneficiary and his/her farm, the plots in which the Superchiva seeds were planted, the beans varieties traditionally planted, their production and usages, their experience plating beans and especially Superchiva, household socioeconomic characteristics, food intake and dietary diversity. At the end, some questions about the acceptance of some sensory and culinary characteristics and their WTP for this variety in the market were also asked. In this study participants were asked about their WTP for 1 lb of Superchiva seed. There is no bean seed market in Guatemala, the reference used by the respondents was the bean grain's market price. No elicitation method for WTP was applied here.

As in the consumer study, a 7-point Likert scale was used and the sensory attributes evaluated were also the same. The agronomic characteristics tested were: yield, crop management, drought resistance, flood resistance, low fertility resistance, pest resistance, diseases resistance, storage and market acceptance.

5.2.4 Sampling Design

Grain acceptance study

Power calculations were conducted to determine a statistical significant number of respondents to be surveyed for the consumer acceptance study in northwest Guatemala.

Bean prices in northwest Guatemala vary by color. Red and white bean varieties are the most expensive and are usually consumed on special occasions, while black varieties, which are consumed daily, are the cheapest ones. In July 2013, the average market price for black bean varieties was 5 Quetzals per pound (1 pound = 0.46 kg). Based on previous studies (Chowdury et al., 2011, Meenakshi et al., 2012; Banerji et al., 2013) a 15% effect on WTP was anticipated corresponding to 0.5 Quetzals with a standard deviation of 2.5 Quetzals. Using a significance level of 5% and a power of 0.8, a sample size of 120 households (HH) per treatment (3 treatments) was estimated.

Then, the sampling strategy established a minimum sample size of 360 households from different communities in the San Sebastian Huehuetenango municipality. However, as there was no reliable secondary data from any recent census or any type of official information to establish a reliable population or household numbers in the municipality, the study asked local experts and community leaders in the study site to estimate the current population numbers in each community.

Data collection took place just before the harvesting season coinciding with the rainy season, which made transportation of the enumerator teams to certain communities difficult, if not impossible. Moreover, the more remote a community was, the higher the security risks were and the more reluctant locals were to participate in any kind of study. As a result, a list of 20 accessible and less remote communities was drawn up, from which 12 were randomly chosen. Because of the lack of household lists in these communities, these were drawn up with the help of the community leaders. The number of participating households per community was determined according to the relative proportion of the population among the listed communities. Within these communities enumerators selected every 5th household on the list in communities with 250 or less households, or every 7th household on the list in those communities with more than 250 households; and selection was proportional to the community's size. As a result, we obtained a self-weighing sample of households, which was representative of the most important bean production areas in the municipality of San Sebastian Huehuetenango.

Seed acceptance study

In 2014, the Ministry of Agriculture, Cattle and Food of Guatemala (MAGA) and the Inter-American Institute for Cooperation on Agriculture (IICA) implemented a project that distributed seed of the iron-enriched bean variety Superchiva in 12 departments across the country, reaching more than 1,050 beneficiaries in 98 municipalities and 208 villages. MAGA received 7,500 lb of seed and IICA received 500 lb of seed. Each institution was free to decide the quantity of seed that would be given to each beneficiary and how they were selected. MAGA gave on average 5.57 lb of seed to each farmer while IICA gave 11.20 lb on average to each farmer. MAGA chose its beneficiaries from the farmers enrolled at the Rural Development Learning Centers (CADER) in the municipalities participating in the "Hambre Cero" (Zero Hunger) governmental program. Each municipality had 10–25 CADER, and each received 50 lb, which was distributed among their beneficiaries. The regional extension agents or the CADER's promoters chose 10 farmers among their beneficiaries based on farmers' willingness to participate in the project. IICA gave the seed to two farmers' organizations which were part of the "Siembras para el Futuro" (Planting for the Future) program because these were in an agro-ecological area suitable for Superchiva production, they had available land to take part in the project and most of the produce grown was traditionally used for farmers' families' consumption.

Due to the severe drought that affected Guatemala in 2014, many beneficiaries lost most or part of their Superchiva plantations. The most affected regions were excluded; the number of departments included dropped to 8 from the original 12, the municipalities decreased from 98 to 44 and the number of beneficiaries dropped from 1,053 to 498. Although low, the 498 beneficiaries that had not been affected by the drought were surveyed as this number was a significant sample of the total number of beneficiaries of this program.

5.2.5 Respondents' market participation

Market participation varies among respondents depending on if they are consumers and producers at the same time or if they are only consumers. Market participation is defined by the proportion of production the respondent sells and/or purchases in the market. Based on that, the respondents were divided into four groups according to their market participation when each data collection took place. The segmentation criteria for consumers was the proportion of their daily consumption of beans satisfied by their own production; a proportion of 50% or lower was considered to be high market participation as consumers have to get much of their beans in markets. For producers, the criteria were the proportion of annual bean production sold at markets. High market participation was defined as a proportion of 50% or higher. The four groups are:

a. Autarkic: Respondents without or poor market participation. Don't purchase or sell a significant proportion of their beans or production at markets (less than 10%).
b. Net sellers (producers with high market participation): Sell 50% or more of bean production in markets and satisfy more of 50% of their demand by self-production.
c. Net purchasers (consumers with high market participation): Purchase 50% or more of their bean grain production in the markets and don't sell a significant proportion of their production.
d. Market dependent: Respondents selling 50% or more of their production and purchasing 50% or more of grain requirements.

Based on this segmentation, respondents' distribution in both studies is shown in Table 5.2. Consumer with high market participation represented the higher proportion of the whole sample (63.48%) and the market dependents were the lowest proportion (3.14%). There were significant differences in the distribution by study; in the grain acceptance study net purchasers had the higher proportion (80.22%) and autarkic had the lowest (5.01). In the seed acceptance study, autarkic had the highest participation (49.12%) and market dependents had the lowest (0.29%).

Table 4.8. Respondents' segmentation according to their market relation

	Autarkic	Net sellers	Net purchasers	Market dependent
Grain	5.01%	8.91%	80.22%	5.85%
Seed	49.12%	4.68%	45.91%	0.29%

Source: Author's estimation

5.3 RESULTS

In this section the main results of the hedonic test and WTP methods conducted with consumers and producers in Guatemala are presented and compared.

5.3.1 Respondents' characteristics

Table 5.3 presents the key respondents and household socioeconomic characteristics, by type of respondent (consumer or producer). The key socioeconomic characteristics listed are those hypothesized to affect respondent preferences based on a literature review of the determinants for acceptance or adoption of staple crops.

Table 4.9 Socioeconomic characteristics by groups (t-test)

Variable	Definition	Grain	Seed	Prob > t
		Mean (S.D.)		
Age ^{c}	Respondent's age (in years)	36.25 (12.34)	43.54 (12.65)	0.00
Gender^{c}	Respondent's gender (1 if male)	35.6%	84.0%	0.00
Literacy	1 if respondent knows how to read and write	75.7%	79.7%	0.23
Education (yrs)	Years of education	3.64 (3.21)	4.10 (5.11)	0.19
The Progress out of Poverty index (PPI)	HH Poverty level according to Grameen Foundation Index	64.4%	62.7%	0.24
Associativity ^{c}	1 if any household members belong to any association or cooperative	13.3%	61.7%	0.00

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level.

Source: Author's estimation

Age, gender and level of associativity were statistically different between both groups. On average, when comparing consumer groups, for men in the producers group, the average age and the associativity level were higher. Those differences were as expected as farmers were traditionally men, older and traditionally were members of any type of association.

5.3.2 Differences on sensory hedonic testing distribution between seed and grain testers

To evaluate if there was any differences between the distribution of the sensory index across the different market participation groups between those respondents testing seed and those testing grain, a Chi–Pearson test was estimated (Table 5.4). The null hypothesis tested was: Sensory index is not related to market participation groups. A p-value <0.05 rejects this null hypothesis.

In order to make the sensory evaluation results comparable between both studies, a sensory index was built using the arithmetic mean of the hedonic scores for the six sensory attributes evaluated (i.e. color, size, taste, thickness, time of cooking and general evaluation). To keep it categorical, those values higher than 0.5 were matched with the immediately upper integer and those equal or lower to 0.5 were matched with the immediately lower integer.

Table 5.4 shows the distribution on this sensory index by respondent group. In the case of the grain acceptance study, the distribution was homogeneous across groups (p –value = 0.013). On average 75% of the respondents liked very much the iron-enriched bean variety. For the seed acceptance study, the distribution was different across market participation groups (p-value = 0.917). Autarkic and net purchasers had similar liker distribution. Those respondents with no relationship with the market at all or as sellers had a more equitable distribution among the sensory indexes. For those who had a strong relationship with the market as sellers, their sensory indexes were clustered between 6 and 7, showing that this variety's attributes, agronomic and sensory, are according to market requirements. In general, the distribution of the sensory index across market relation groups was different between seed and grain testers.

Table 4.10 Sensory index distribution by respondents groups

	Autarkic		Net sellers		Net purchasers		Market dependent	
Grain acceptance study	4	0%	4	0%	4	0.35%	4	0.56%
	5	5.56%	5	3.13%	5	1.74%	5	0%
	6	22.23%	6	21.89%	6	17.71%	6	19.04%
	7	72.23%	7	75.20%	7	78.82%	7	76.2%
Difference in distribution								
Pearson Chi-square (p-value)							0.013	
Seed acceptance study	2	1.26%	2	0%	2	0.69%	2	0%
	3	3.15%	3	0%	3	3.46%	3	0%
	4	2.52%	4	0%	4	6.93%	4	0%
	5	10.07%	5	0%	5	5.55%	5	0%
	6	27.68%	6	18.75%	6	22.22%	6	100%
	7	55.35%	7	81.25%	7	55.55%	7	0%
Difference in distribution								
Pearson Chi-square (p-value)							0.917	

Source: Author's estimation

5.3.3 Relation between sensory and agronomic evaluation to the different market participation groups among seed testers.

After finding that the sensory evaluation results varied between seed and grain testers, the relationship between sensory and agronomic evaluations with the different market groups was tested using Chi-Pearson test (Table 5.5). The hypothesis to be tested is: sensory /agronomic index is not related to the specific market group. A p-value <0.05 rejects this hypothesis. The agronomic index is the arithmetic mean of all the hedonic scores for the agronomic attributes evaluated as yield, drought resistant, crop management, flood resistant, fertility, etc.

In the case of sensory index, in all market participation categories, the null hypothesis was accepted except for autarkic. For those respondents with any kind of participation in market, as consumer, seller or both, their hedonic evaluation towards the grain's sensory attributes was influenced by this market participation. In the case of agronomic index, it was related to all the market participation categories including autarkic.

Table 4.11 Chi-person test results to evaluate the relation between sensory and agronomic index to the different market relation categories. (p-value).

	Sensory index	**Agronomic index**
Autarkic	0.00a	0.31
Net-seller	0.69	0.16
Net-purchaser	0.06	0.18
Market dependent	0.85	0.51

a Null hypothesis is accepted

Source: Author's estimation

5.3.4 Willingness to Pay (WTP) for iron-enriched bean variety

Market price ranged between Q. 4.5 and Q 5.5 with a mean of Q 5 per pound of bean (grain and seed) during the period in which both studies took place. Then, WTP bids falling into this range were considered as equal to the market price. Respondents' WTP bid were distributed into the following groups: below market price (< Q. 4.5), equal to market price (Q 4.5 – Q 5) and over the market price (> Q. 5) (see Table 5.6). For grain, the average WTP was Q. 4.90, being the market dependents who stated the higher value Q 5.11, showing that the iron-enriched bean variety fulfilled or even exceeded consumers' market expectations. The distribution across respondents' market participation was homogenous; the highest proportion (59.61% in average) stated a WTP equal to market price, showing that on average, consumers were indifferent about the main attributes of the iron-enriched bean variety and the local variety they traditionally found in markets and fields. For seed, the average WTP was higher at Q. 5.91 exceeding the net purchasers who state an average WTP of Q. 6.01 and the autarkic who stated an average of Q. 5.82. Both groups showed a higher proportion of respondents bidding a WTP higher than the market price. Those results show a higher acceptance of agronomic attributes than sensory ones. Unlike the grain acceptance study, the distribution across respondents groups was not homogenous for seed testers.

Table 4.12 Average WTP and its distribution by respondents' market relationships.

		Autarkic	**Net sellers**	**Net purchasers**	**Market dependent**	**Total**
Grain acceptance study	Average WTP (S.D.)	Q. 4.83 (0.91)	Q. 4.84 (0.88)	Q. 4.89 (0.73)	Q. 5.11 (1.00)	Q. 4.90 (0.77)
	Lower than market price	22.23%	25.01%	25.01%	19.04%	24.52%
	Equal market price	66.68%	59.39%	59.73%	52.38%	59.61%
	Higher market price	11.09%	15.60%	15.26%	28.58%	15.87%
Difference in distribution Pearson chi-square (p-value)						0.00
		Autarkic	Net sellers	Net purchasers	Market dependent	Total
Seed acceptance study	Average WTP (S.D.)	Q. 5.82 (12.33)	Q. 5.33 (0.70)	Q. 6.01 (15.75)	Q. 5 (0)	Q. 5.91 (13.84)
	Lower than market price	14.93%	0%	18.99%	0%	16.03
	Equal market price	41.79%	77.78%	6.33%	100%	36.54
	Higher market price	43.28%	22.22%	74.68%	0%	47.43%
Difference in distribution Pearson Chi-square (p-value)						0.546

Source: Author's estimation

5.3.5 Role of respondents' market relation with WTP for iron-enriched bean variety

An Ordinary Least Square model was estimated for each one of the studies (grain and seed) using WTP for the iron-enriched bean variety known as Superchiva as a dependent variable. Each model included the most important socioeconomic variables that have shown some significance in previous studies that evaluated the acceptance and adoption of new staple crops varieties in developing countries (see for example, Awotide et al. (2013), Kelsey (2013) and Asfaw et al. (2010)) as gender, years of education, wealth (the Progress out of Poverty Index (PPI) was used as a proxy), respondents' market participation and the sensory index. In the case of seed, an agronomic index was also included. The interaction between the socioeconomic variables and the market participation groups were also included. The results of these models are shown in Table 5.7.

For the seed model, older male and market dependent respondents showed a WTP for 1 pound of seed Q. 1,87 higher than autarkic younger women. Usually men, especially older men, were those in charge of planting decisions (i.e. which variety to plant, in which area, and so on). This result showed that agronomic attributes were more important for those market dependent producers than for the other groups of respondents. Similarly, producers with some level of associativity, had a WTP Q. 1.18 higher than those not related to any producer association, which also reflects the higher value given to agronomic attributes to those more market oriented producers, since most of the association were market orientated.

In the case of grain, net-purchaser males stated a WTP for the iron-enriched bean variety at Q. 0.22 lower than net-purchaser women. In the case of market-dependent male, they stated a WTP at Q. 0.76 for the iron-enriched variety lower than market-dependent women, reflecting a potential lower appreciation for nutrition and health issues by men compared to women. Men gave a lower market value than women for more nutritious and healthy food. Similarly, the older the respondent was, the higher their WTP for the iron-enriched bean variety. Older people were usually more aware than younger people about nutrition and health benefits of iron-enriched beans.

Table 4.13 Determinants of WTP for the iron-enriched bean variety in Guatemala according to respondent's relation to markets by study (Grain and seed).

Variables	Seed model	Grain model
Age	-0.02[b] (0.01)	0.04[a] (0.02)
Gender	-0.41 (0.43)	-0.92[b] (0.80)
Years of education	-0.05 (0.08)	0.06 (0.09)
Associativity	1.18[a] (0.63)	0.49 (0.60)
Poverty index	0.08 (0.14)	-0.00 (1.08)
Net seller	-0.97 (0.80)	0.85 (0.16_
Net purchaser	-0.94 (0.68)	-0.53 (0.04)
Market dependent	-0.23[b] (1.00)	0.03[a] (0.13)
Netseller x age	0.02 (0.01)	-0.03 (0.06)
Net seller x gender	-0.10 (0.52)	-0.35 (0.15)
Net seller x years of education	0.10 (0.09)	-0.13 (0.10)
Net seller x associativity	-1.12 (0.79)	0.85 (0.55)
Net purchaser x age	0.02 (0.01)	0.04 (0.04)
Net purchaser x gender	0.39 (0.44)	-0.44[b] (0.11)
Net purchaser x years of education	0.05 (0.08)	0.25 (0.16)
Net purchaser x associativity	-0.90 (0.65)	0.84 (0.97)
Market dependent x age	0.04[b] (0.02)	-0.02 (0.04)
Market dependent x gender	1.02[a] (0.58)	-1.01[b] (0.66)
Market dependent x years of education	0.14 (0.09)	-0.20 (0.02)
Market dependent x age	-1.14 (0.78)	-0.35 (0.86)
-Cons	1.06[c] (0.67)	1.14[b] (1.81)
N	359	342
Likelihood-ratio test for heteroscedasticity (Prob > chi^2)	0.07	0.02
Prob>F	0.08	0.02
R^2	0.10	0.18
Adj R^2	0.02	0.04

Standard errors in parentheses

c= statistically different at 1% significance level; b= statistically different at 5% significance level; a= statistically different at 10% significance level

Source: Author's estimation

5.4 CONCLUSIONS

To maximize biofortification impact, biofortified crops must be adopted and produced by farmers and accepted and consumed by target populations in rural and urban areas. Micronutrient deficiencies are most prevalent in margined rural areas where access to varied and nutritious food and nutritional programs is limited. These areas are characterized by small farmers with limited access to markets that are producing staple crops such as beans, maize, cassava, etc., mainly for their own consumption, and are the main suppliers of these crops in low-income countries. Most of biofortification's target populations are producers and consumers at the same time, and their acceptance of biofortified crops is critical to reach biofortification's goal of reducing micronutrient deficiency or hidden hunger globally.

Several consumer acceptance studies of biofortified crops have been carried out to date in rural areas in Africa, Asia, and Latin America. All of them have evaluated the acceptance of grain from the consumer perspective but none have evaluated how aspects related to producers' perspectives such as their acceptance of agronomic characteristics (seed) or how their perception changed when trying the crops several times under diverse conditions. This paper evaluated if there was any differences in consumer's acceptance of an iron-enriched bean variety between those respondents receiving seed and those receiving grain for testing, by comparing the results of two studies conducted in rural Guatemala to evaluate the consumer acceptance of an iron-enriched bean variety (Superchiva). In the first study, rural respondents (most of them bean producers) received grain for cooking and eating once; in the second study, bean producers received seed for planting to cook and eat the grain they harvested, having a chance to eat it several times. For this analysis, respondents were classified based on their relationship to markets into four groups: autarkic, net sellers, net purchasers, and market dependents.

As a result, differences were found in how the consumers valued the iron-enriched bean variety attributes depending if they had received seed or grain for testing and on their market participation. Among those testing grain, the distribution of the sensory liking was homogenous across the market participation groups, while for those testing seed, this distribution differed, and market participation seemed to play a role in sensory testing results when respondents had the chance to try seeds and consume the grain on a number of occasions. The extent of the respondents' market participation had a significant impact on the agronomic evaluation for seed testers, but for those testing grain, their sensory evaluation was related to market participation for those with little or no market participation (autarkic). Seed testers had more time to evaluate the variety and try the grain several times, which allowed them to compare it more in detail with those other local varieties in the market, increase the chances of adoption if the iron-enriched bean variety was preferred.

Among the grain testers, the WTP was homogenous regardless of their relationship to markets, but among seed testers, the average WTP was higher than grain testers. Autarkic and net purchasers showed a higher WTP, with a higher proportion stating a value over the market price. Being a grain or seed tester had an impact on WTP and in the case of the second group, the market relationship affected the acceptance of the iron-enriched bean variety.

The link between market participation and the acceptance of an iron-enriched variety was validated through an econometric analysis finding that producers' WTP for seed depended mainly on their age, gender, and market participation, showing that for older men who were strongly related to markets, agronomic attributes were important. Male testers of grain who had high dependency on markets showed lower appreciation for sensory attributes and WTP for the iron-enriched variety than the other groups did.

Although the two studies included in this analysis were carried out in most cases in different regions and the elicitation methods used were different, we can conclude that to get more accurate results on the acceptance of a high nutritional variety, respondents market participation must be taken into account to establish if seed or grain should be tested. Respondents who are producers and consumer at the same time test and accept the iron-enriched bean grain, but this doesn't mean that they will produce and consume in the future; this decision depends on their market participation and their agronomic valuation of the seed.

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6. GENERAL DISCUSSION AND CONCLUSIONS

Biofortified varieties are a novel strategy to fight micronutrient deficiencies or hidden hunger. In order for biofortification to be an efficient complementary strategy reducing micronutrient deficiencies, biofortified varieties must be accepted and consumed by target populations, i.e. people suffering from micronutrient deficiencies. For this reason, several studies have been carried out to evaluate the acceptance of those varieties in different countries however, mixed results have been obtained.

Biofortified crops might be classified into two different groups. Those with visible nutritional traits as cassava and sweet potato enriched with vitamin A that changes their color because of the higher beta-carotene content, and those with invisible or non-visible traits as those enriched with minerals as iron and zinc which does not change its visible appearance. Crops with invisible traits can be considered as *credence goods*. These goods represent a challenge to consumer acceptance studies because consumers cannot observe their utility immediately. That is why information plays a significant role in their acceptance. Nutritional information can help overcome those constraints related to credence goods, offering the information that consumers need in order to form an opinion based on the potential utility that they will receive in the future from the consumption of biofortified varieties. But the impact of this information depends on various socioeconomic consumer characteristics such as gender and market participation. These characteristics not only influence consumer preference for a specific product feature but will also determine the final impact that the nutritional information might have on the acceptance of those products.

In this sense, this dissertation contributes to the research on consumer acceptance of biofortified crops in two ways. The first is methodological, i.e. by analyzing how some socioeconomic consumer characteristics define preferences for specific sensory attributes of biofortified crops;

and the second is empirical, through examining how some of those characteristics might influence the impact that nutritional information –the strategy traditionally used to promote biofortified crops– might have on consumer acceptance for those varieties.

6.1 MAJOR RESULTS AND ACHIEVEMENTS

6.1.1 Methodological contributions

This dissertation closes several knowledge gaps which have so far not been addressed in the scientific literature evaluating the acceptance for biofortified crops. Although biofortification does not generate any visible impact on seed or crop appearance –mainly those biofortified with minerals– some differences can be observed as a result of the breeding process between different varieties. Differences in grain size, brightness, and cooking time might be observed. Those differences might affect the perception consumers have for biofortified varieties indistinctly of their nutritional status or the information received. Then, to understand how consumers' socioeconomic and cultural characteristics define their preferences for some specific attributes will help to understand some of the reasons behind the mixed results found in prior consumer acceptance studies carried out for biofortified crops and predict how acceptable will new varieties be in some specific population segments. Those relations between consumer characteristics, organoleptic attributes of varieties and type of information provided must be introduced in future studies evaluating consumer acceptance for biofortified varieties.

6.1.2 Empirical findings

The empirical objective of this dissertation is the identification of the relations among consumer characteristics, their preference for specific biofortified sensory attributes and the impact of nutritional information on those preferences. The understanding of those relations will increase the accuracy of future consumer acceptance research of biofortified crops and similar products and will shed some light on the reasons behind the mixed results found in different studies that analyzed consumer acceptance for biofortified varieties up to date. These mixed results are shown in chapter 3 where consumer acceptance of an iron biofortified bean variety in Guatemala, employing the willingness to pay methodology was evaluated, showing that nutritional information does not have any impact on consumer acceptance of this variety. On the other hand, information repetition had a positive impact mainly on respondents with a higher level of education. These results are different from those found in similar studies in other countries with different biofortified crops. The mixed results led us to inquire into some potential reasons.

Consumer characteristics and their preference for some specific sensory attributes

Chapter 2 shows that consumer's socioeconomic and cultural characteristics define the preferences for specific sensory attributes of biofortified crops and the impact that nutritional information might have on their acceptance. In this chapter, characteristics defining consumer acceptance for main organoleptic attributes of an iron bean variety were evaluated. According to this, most of the characteristics that defined consumer preference for attributes such as color, flavor, and size are those related to bean production and market orientation. These results agree with the results found in chapter 5, which indicates that there are differences in how respondents value an iron biofortified variety, and this depends on their market orientation. Furthermore, these differences also depend on whether respondents are testing seeds and grains or only grains.

Most consumer acceptance studies implemented with biofortified crops have been carried out using biofortified grains, but most of the respondents are producers as well, who are also interested in the agronomic attributes of the varieties. These consumer preferences might vary based on their relation to markets and the possibility of testing seeds and grains, or only grains.

In chapter 5 this link between market participation and the acceptance towards an iron biofortified variety was validated. Those results show that market participation plays a relevant role in sensory testing results when respondents have the chance to test the seeds and consume the grains several times. Among grain testers, their acceptance was independent of their relation to markets; the opposite was observed with seed testers, in which market relation had a significant impact, presumably because most of their income is related to this.

Consumer characteristics and nutritional information impact

According to the results shown in chapter 4, the impact of nutritional information depends on some specific socioeconomic characteristics as gender. The results indicate that nutritional information has a higher positive impact on women than on men, and its repetition tends to have a positive impact on more educated men. Then, different types of messages or communication strategies must be implemented depending on the respondent's gender, education level, and other socioeconomic characteristics.

6.2 POLICY IMPLICATIONS

These results give rise to several implications for the design and implementation of an effective strategy for the dissemination of biofortified crops. In this sense, effective means achieving a higher acceptance among those persons consuming biofortified products. The first implication is related to the design of a specific dissemination strategy according to some specific attributes of the biofortified crop to be promoted. The second implication is the design of promotion strategies considering several specific consumer characteristics such as gender and market participation.

Consideration of specific crop attributes

Specific crop attributes such as color, taste, grain size, among other sensory characteristics, define consumers' preferences and acceptance for a product (Costell et al., 2010). In the case of beans in Guatemala, characteristics such as color, cooking time, flavor and cooked bean thickness are stated as the most important characteristics for a bean variety to be accepted and consumed in households. This means that these attributes are more important for women than for men since crops decision purchase and cooking are female related activities in rural Guatemala. Darker and brighter colored bean grains are also preferred by women, as those attributes are perceived as a sign of freshness. Less cooking time means that the grains are fresher, and consequently, less wood for cooking is required, and therefore, their acceptance and consumption is higher. Flavor and cooked bean thickness are important, especially for children´s acceptability.

Based on consumer behavior economics, preferences for specific product attributes will be defined not only by consumers' gender but also by other external variables influencing consumer's decision process (Bray 2008), such as socioeconomic, cultural and biological aspects (Moerbeek & Casimir, 2005). In rural Guatemala, preferences for attributes such as color, size and cooking time are defined in most of the cases by consumer's characteristics related to their bean production status and market orientation. In this direction, being a non-buyer of beans or being a bean producer or a bean consumer determines some of the preferences for those attributes. Further, nutritional information does not play a significant role in consumer preference formation, as preferences are mainly culturally formed and market-related, and less influenced by socio-demographic characteristics. These aspects must be considered when designing a communication strategy to promote biofortified crops.

Gender andnutritional information

The role of nutritional information on food choice may be different for men compared to women. For men, health is a less important motivational factor when making food choices compared to women, i.e. men prefer taste and convenience over healthy food choices (Wardle *et al.*, 2004). Other authors stated that men's food choices are influenced by their health beliefs and behaviors, which are defined by a stereotypical and socially prescribed masculine role. According to Courtenay (2000) this kind of masculine stereotypical behavior is more common in lower socioeconomic groups (men are guided by self-concern and messages that contain agentic sentiments, meanwhile women are guided by both themselves as well as by others, and are easier persuaded with messages that have collective elements (Putrevu, 2001). These differences influence how marketing communications are processed and evaluated by men and women.

Results obtained in this dissertation research agree with the evidence in the existing literature, stating that women are more sensitive to health and nutrition messages than men and that men require repetition of this kind of information in order for it to have a positive impact. Based on these results, to provide nutritional information and its repetition could be a good strategy to increase consumer acceptance towards biofortified crops, especially among more educated men and households. But biofortification must impact mainly –but not only– poor households incapable of fulfilling their nutritional requirements, for which nutritional information and repetition strategies must be complemented by other strategies as pictures, videos, among others, and focus not only on the nutritional attributes of the biofortified crops but also on agronomic and market-related attributes.

Consumers' market participation and their acceptance for biofortified grains or seeds

Consumers' preference for biofortified variety attributes depends on some socioeconomic characteristics, mainly those related with respondents' market orientation. Hence, the acceptance of a biofortified variety may differ on whether the respondent is a producer and/or a net buyer/net seller of the biofortified crop. This relation to market orientation is also important in terms of the type of product tested. It must be noted that all consumer acceptance studies are based on the evaluation of biofortified grains, but most of the respondents are also producers, so the agronomic evaluation of the biofortified seeds might be more important than the grain evaluation itself.

6.3 DIRECTIONS FOR FURTHER RESEARCH

The integration of relevant socioeconomic characteristics and other external variables in consumer acceptance studies of biofortified crops are imperative in order to have more accurate results allowing us to design more effective diffusion strategies and to reach a wider number of consumers.

Results of the nutritional information impact evaluations on consumer acceptance of biofortified crops are of a mixed nature across different studies carried out in recent years. In general, it might be concluded that information plays a significant role to promote biofortified crops all over the world. Different types of messages have been tested, long as opposed to short, with a positive frame versus a negative one, through public sources versus other types of sources, and so on. But, what defines the real impact of information provision is a combination of both the type of message and specific consumer characteristics as gender, market relation, and education level.

Thus, further research must be carried out including both aspects, evaluating how different types of messages impact men and women, or how different is this impact on consumers with low market orientation versus those with high market exposure. Moreover, how different are those results when respondents are consumers also producing crops to sell in the market and are testing seeds and grains versus those testing only grains, as have been previously done. Respondent segmentation according to their market orientation and the possibility of testing seeds and grains at the same time is imperative to achieve a better quantification and understanding of the differences.

However, there is still an enormous range of alternatives to be included as nutritional information to find a successful strategy for the dissemination and acceptance of biofortified products as well as similar ones. This dissertation seeks to make an important contribution in the analysis and integration of the existing relations among information and other external variables on consumer acceptance analysis of credence goods as biofortified varieties, being a starting point for future research.

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  Latin-American Biosafety Project and Impact Assessment Project.

- Coordinating projects related with socioeconomic impacts of genetically modified organism in megadiverse countries (Colombia, Perú, Costa Rica y Brazil).
- Assessing the ex – post economic impact of improvement varieties of cassava, beans, rice and forages in Colombia and Latin America.
- Support in Monitoring and Evaluation project in Coffee improvement quality in Ecuador and Colombia

- **International Center for Tropical Agriculture (CIAT) 2007 - 2010**
  Economist. Research Assistant

  AgroSalud

- Coordinating projects related to producer acceptability and adoption of biofortified crops in Latin America.
- Assessing the ex – ante impact of biofortified rice, beans, cassava and maize in Latin America using Disability - Adjusted Life Years (DALYs) methodology.

- **International Center for Tropical Agriculture (CIAT) 2003 - 2007**
  Economist. Research Assistant

  Latin American and Caribbean Consortium for Cassava Research and Development. CLAYUCA.

- Coordinating studies related with cassava processing projects in CLAYUCA's countries partners.
- Consolidating and processing cassava data for Colombia and other Latin America countries.
- Assessing ex-ante and ex-post socioeconomic impact of processing cassava projects.

- **Valle del Cauca Farmer's & Cattle Rancher's Association (SAG) 2003**
  Economist assistant

  Valle del Cauca milk chain supply.

- ***Corporación Autónoma Regional del Valle del Cauca (CVC)*** 2002
  Assistant Consultant for Socioeconomic Project Assessment.

- ***International Center for Tropical Agriculture (CIAT***) 2001
  Intern at the CLAYUCA Project (Latin American and Caribbean Consortium for Cassava Research and Development).

<u>PUBLICATIONS:</u>

- Pérez S., Oparinde A., Birol E., Gonzalez C., Zeller M., (2018). Consumer acceptance of an iron bean variety in Northwest Guatemala: The role of information and repeated messaging. *Agriculture and Food Economics*, 6(14). 1-23.
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- Gottret, M.V., Escobar, Z. y Pérez Salomón. 2002. “El sector yuquero en Colombia: desarrollo y competitividad”. La yuca en el tercer milenio: sistemas modernos de producción, Procesamiento, Utilización y Comercialización. Cali, Colombia: CIAT-CLAYUCA. Publicación CIAT No. 327, p. 340-376.

- Pachico, D., Escobar, Z., Rivas, L., Gottret, m.v., y Pérez, Salomón. 2001. “Environmental Risk Assessment of Transgenic Crops: An International Comparison”. Presentado ante la sociedad internacional de medición de impactos.Cartagena, Colombia. Mayo 26 a Junio 1 de 2001.
- Pachico, D., Escobar, Z., Rivas, L., Gottret, m.v., y Pérez, Salomón. 2001. “Income and Employment Effects of Transgenic Herbicide Resistant Cassava in Colombia: a Preliminary Simulation”. Presentado en la conferencia internacional sobre investigación en agricultura biotecnológica. Ravello, Italia. Junio 15-18 de 2001.

Reviewer for:

- Ecology of Food and Nutrition
- Public Health Nutrition.

<u>PRESENTATIONS AND SEMINARS:</u>

- Pérez S. Poster presentation: Developing Country Consumers' Acceptance of biofortified foods: a synthesis. 4th Micronutrient Forum Global Conference. Cancún -México, October 23 – 28th, 2016.

  Pérez S. Oral presentation: Information and Consumer Acceptance of Iron Beans. Evidence from Experimental Auction sin Guatemala. Organized symposia: “*Developing country consumer acceptance of nutritionally enhanced biofortified foods: Evidence from field experiments in Africa, Asia and Latin America*”. 29th Triennal International Conference of Agricultural Economist (ICAE). Milan, August 8-14, 2015.
- Pérez S. Poster presentation: Characterizing Consumers' Preference for an Iron Bean Variety in Northwest Guatemala: A Sensory Evaluation. 29th Triennial International Conference of Agricultural Economist (ICAE). Milan, August 8-14, 2015.
- Pérez S. Oral presentation: The impact of national biosafety legislation on social returns to investment in development of GM maize in Brazil and Colombia. Oral presentación. International Consortium on Applied Bioeconomy Research. Nairobi, Kenia. June 2014.

- Pérez, S. Biofortification, an alternative to reduce food insecurity and its adverse effects in developing countries. A Honduras case study. Poster presentation. 1st EAAE/AAEA Seminar 115th EAAE Seminar "The Economics of Food, Food Choice and Health". Freising, Germany, September 15 – 17. 2010
- Pérez, S. Evaluation of the Economic Feasibility of a Biofortification Intervention in Nicaragua. Poster presentation. The Second Annual Meeting of the Micronutrient Forum. Beijing, China, May 12–15. 2009.
- Pérez, S. Análisis económico del impacto potencial de los cultivos biofortificados. XX Reunión Frijolera de Costa Rica. San José, Costa Rica. Agosto 20 – 22. 2008.
- Pérez, S. Evaluación del impacto económico de la intervención con cultivos biofortificados con hierro en Honduras. Oral presentation. LIV Reunión Anual "Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales"(PCCMCA). San José. Costa Rica. April 14 – 18. 2008.
- Pérez, S. Impacto económico de la biofortificación de cultivos básicos con nutrientes. Oral presentation. LIII Reunión Anual "Programa Cooperativo Centroaméricano para el Mejoramiento de Cultivos y Animales"(PCCMCA). Antigua. Guatemala. April 23 – 27. 2007.

<u>ADVISING:</u>

Masters Student Advisees at CIAT

- Universidade Técnica de Lisboa. Portugal. Ana Rita Gomes Domingues. Validation of the implementation of rural and social refineries in Colombia. 2010.
- Copenhagen University. Denmark. Anne Balling Jacobsen. Department of Human Nutrition Faculty of Life Sciences. Ex-ante economic impact assessment of introducing cassava or maize biofortified with pro-vitamin A in four Latin American countries. 2008.

INSTRUCTION:

- Science and Technology Institute of Guatemala (ICTA). Stata. June 20-23, 2015.International Center for Tropical Agriculture (CIAT). Economic Surplus Analysis Model (MODEXC). Impact Assessment Methodologies Course (CORPOICA). October 26 – 27, 2011.
- Corporación Colombiana de Investigación Agropecuaria (CORPOICA) – Turipana. Economic Surplus Analysis Model (MODEXC). November 11 – 12, 2009.

LANGUAGES SKILLS:

- Spanish: Mother language
- English: Toefl score: 91 points (expired in 2015)
- Portuguese (Medium)

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AUTHOR'S DECLARATION

I hereby declare that this doctoral thesis is a result of my personal work and that no other than the indicated aids have been used for its completion. All quotations and statements have been indicated. I did not accept assistance from any commercial agency or consulting firm. Furthermore, I assure that the work has not been used, neither partially nor completely, for achieving any other academic degree.

Cali, 15th of May 2019

Salomón Pérez Suárez